JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 44 February, 1951 No. 1

CONTENTS

The Time Factor in Biological Control ..... Curtis P. Clausen 1
Aerial and Ground Application of Insecticides for Pre-Season Control of Alfalfa Weevil ..... Ellsworth Hastings and J. H. Pepper 9
Biological Control of Certain Cotton Insects and the Application of New Organic Insecticides in Perú ..... Johannes E. Wille 13
Further Studies of Repellents in Alaska .... K. H. Applewhite and H. F. Cross 19
Insecticidal Effectiveness of Sprays and Aerosols Containing Allethrin ..... J. H. Fales, R. H. Nelson, R. A. Fulton and O. F. Bodenstein 23
The Apple Flea Weevil ..... F. G. Mundinger 28
Treatment of Mosquito Larvae with Radioactive Phosphorus ..... W. W. Yates, C. M. Gjullin and Arthur W. Lindquist 34
Biological Control of Mealybugs Infesting Commercial Greenhouse Gardenias .. .. Richard L. Doutt 37
Sugars and Protein in the Corn Plant as Related to Nutrition of the Corn Borer. ..... G. T. Bottger 40
The Effect of Alfalfa Dehydration Upon Residues of Aldrin, Chlordane, Parathion, and Toxaphene ..... Roy E. Stansbury and Paul A. Dahm 45
Importance of Feeding and Defecation Times of Insect Vectors of Chagas' Disease ..... Sherwin F. Wood 52
Seasonal Variation in the Weight and Ovarian Development in the Worker Honeybee ..... Marshall D. Levin and Mykola H. Haydak 54
Control of the Soil-Inhabiting Grubs of Puerto Rico ..... George N. Wolcott 58
DDT for Control of Stable Fly, or Dog Fly, in Northwestern Florida .... Kenneth D. Quarterman, John D. Parkhurst and William J. Dunn 61
Aldrin and Dieldrin Compared as Grasshopper Poisons ..... A. V. Mitchener 66
Relative Toxicity of Allethrin Analogs to House Flies ..... W. A. Gersdorff and Norman Mitlin 70
Starch and Other Carbohydrates in Relation to Powder-Post Beetle in Freshly Harvested Bamboo ..... H. K. Plank and R. H. Hageman 73
Changing Problems and Procedures in Relation to Grasshopper and Mormon Cricket Control ..... Claude Wakeland 76
Spray Tests on Citrus to Control Fruit Tree Leaf Roller ..... E. Laurence Atkins, Jr. 82
Control of *Hylemya brassicae* in Radishes ..... Loyd L. Stitt 87
Chlorinated Chemical Control of the Sandhill Cutworm ..... Roscoe E. Hill and Martin H. Muma 90
Further Tests of Dibutyl Adipate as a Tick Repellent ..... Philip Granett and Carl F. French 93
Further Evaluation of Butoxypolypropylene Glycol as a Fly Repellent for Dairy Cattle ..... Philip Granett, Harry L. Haynes and Robert W. Helm 97

Scientific Notes:

Honey Bee Activity on Ladino Clover Florets ..... George H. Vansell 103
A Method of Testing the Resistance of House Flies to Residual-Type Insecticides ..... Dale R. Lindsay and Thomas W. Haines 104

Synergism Between Nicotine and Pyrethrum ..... Neely Turner 106
Sodium Fluosilicate as an Activator for Certain Organic Insecticides ..... S. Marcovich 108
Aminophenols as Antioxidants for Pyrethrum ..... Gaines W. Eddy 109
The 1950 Greenbug Outbreak in Oklahoma ..... F. A. Fenton and R. G. Dahms 111
Mange and Fly Control with Lindane in a Piggery ..... Harvey L. Sweetman, ... Lewis F. Wells, Jr., Albert H. Toczydlowski and Steve Moore III 112
The Relative Attractiveness of New Jersey Light Traps Painted (a) Green and (b) Yellow to Puerto Rican *Culicoides* ..... Charles E. Kohler and Irving Fox 112
Alfalfa Seed Production as Influenced by Insecticide and Fertilizer Application ..... E. H. Fisher and K. C. Berger 113
The Toxicity of Certain Organic Insecticides to Different Strains of House Flies ..... R. S. Robertson, Jr. and J. C. Gaines 114
Grasshopper Control ..... J. C. Gaines and R. L. Hanna 116
Emergency Insect Control in North Dakota ..... J. A. Munro and R. L. Post 117
Effect of Abrasive Diluents on the Toxicity of Lindane to the American Cockroach ..... P. G. Piquett and C. V. Bowen 118
Oviposition by the Two-Striped Grasshopper in a Strip-Farming Area .... George T. York 119
Influence of Lime and Nitrogenous Fertilizers on the Population of Greenbugs Infesting Oats ..... F. S. Arant and Calvin M. Jones 121
A Field Test of Some Organic Insecticides for Control of the Armyworm ..... E. T. Hibbs and C. R. Weaver 122
Comstock Mealybug in Ohio ..... C. R. Cutright 123
Development of Green Peach Aphid as Affected by Nutrient Deficiencies in a Host, Nasturtium ..... John S. Barker and Oscar E. Tauber 125
A Method of Dispersing Lindane Vapor in Air ..... W. N. Sullivan 125
Control of Mites on Alfalfa and Clover Seed Crops ..... E. C. Klostermeyer 126
Injurious Effects of *Paracantha culta* on Canadian Thistle in Wisconsin ..... Raymond E. Ryckman 127
Tests with Dieldrin for Control of Japanese Beetle Larvae in Turf ..... J. Alfred Adams 127

Proceedings, Sixty-Second Annual Meeting, American Association of Economic Entomologists 129

JOURNAL OF ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

Vol. 44 February, 1951 No. 1

The Time Factor in Biological Control

Presidential Address, Sixty-Second Annual Meeting, American Association of Economic Entomologists

CURTIS P. CLAUSEN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In previous publications the writer (1939, 1941) discussed briefly the rate of increase that may be expected of effective parasites and predators and the time interval that is required before evidence of commercial control may be expected in the field. The statement was then made that an *effective* parasite or predator might be expected to show evidence of control *at the point of release* within a period of three host generations or three years, and that in all cases the time required is short, often a matter of months rather than years. Several authors have presented detailed mathematical computations, based mainly upon the relative reproductive potentials and length of life cycles of host and parasite, to show that the latter is able to overcome its host only after a long time interval, while other authors, notably Howard (1924), have emphasized that speedy results must not be expected and have suggested that, after a varying period of time following importation, a parasite may adapt itself to local conditions and then exercise control of its host. Howard lists five factors which act to delay field control, one being "The necessity for a rather prolonged period of time to elapse before the parasite, introduced in comparatively small numbers and even with a greater rate of multiplication than its host, can catch up in numbers to the millions of the host insect." The purpose of the present article is to reexamine the subject in the light of such definite information as has since become available from actual biological control projects and to draw from them whatever general conclusions may be permissible. The conclusions reached, if accepted, may have an important bearing on the conduct of current and future projects.

Before proceeding further it is essential to delimit clearly the scope of the discussion. It deals only with parasites and predators that consistently exercise what is termed full commercial control upon the hosts, and with those that are destined to do so. For the purposes of this discussion, full commercial control may be defined as that degree of control beyond which other methods of control are not required or economically practicable. Obviously, we cannot know in advance or predict the final effectiveness of a newly introduced species, but its reactions immediately following colonization may provide excellent clues to its future status. An effective parasite is one which consistently holds its host under control, year after year, irrespective of influences that may tend to cause the populations of the latter to oscillate widely. In other words, the parasite is perfectly adapted to its host and its responses to external influences, such as climatic conditions, are similar. Conditions that affect the host population influence the parasite in the same way, at least to the extent that conditions favorable for host increase are likewise consistently favorable for the parasite.

An ineffective or partially effective parasite may be so because of a differential response to environmental conditions, wherein certain of those favoring the host are adverse to the parasite. When conditions favorable for both, or favorable for the parasite and not for the host, coincide in time the parasite may be able to exercise considerable or even complete control for a variable period, but this is only a temporary condition and the parasite soon reverts to its previous state of ineffectiveness.

In taking up the discussion of specific instances to determine the validity of the

3-generation, 3-year theory, it is first necessary to define the conditions under which it is believed to be valid. It is obvious that a parasite capable of spread of only 100 feet per generation will be able, if released at a single point, to control an infestation one square mile in extent only after a considerable number of generations. The rate of dispersion by a species varies greatly, from a few tree rows per year by *Comperiella bifasciata* How. and about 200 feet by *Anastatus disparis* Ruschka to many miles per generation in some Tachinidae, Ichneumonidae and Braconidae. A test unit of area therefore needs to be adopted that has a direct relation to the dispersion capacity of the particular parasite or predator under consideration. On a rather arbitrary basis this unit of area may be set as that over which the adults of the first field generation will spread from the colony site. With many scale insect and white fly parasites, such as *Eretmocerus serius* Silv., the unit may be five acres or more, while with others, as *Paradexodes epilachnae* Ald., it may be 100 acres or more. This requirement exists only when the release is of a single colony at one point and, of course, the unit may be enlarged indefinitely if the initial releases are distributed throughout the observation area. On this basis we may now proceed to an examination of available data relating to the attainment of full field control by imported natural enemies in past projects that are recognized as successful and for which adequate observational data are available. In all too few cases, however, are the published data as complete as would be desirable for an exact analysis of time requirements.

There are three major pests of citrus in California that provide information that is pertinent to this discussion. The first of these, of course, is the notorious cottony-cushion scale which once threatened to destroy the industry. The biological control of this insect through the importation of the coccinellid beetle, *Rodolia cardinalis* (Muls.), from Australia in 1888–89, was one of the most successful ever undertaken, not only because of the completeness of the control effected, and its consistency year after year, but because that same effectiveness has been attained under diverse climatic conditions in practically all other citrus-producing sections.

The survivors of the three initial shipments from Australia to California, totaling 129 beetles, were liberated on a caged tree at Los Angeles in December, 1888, and January, 1889. By the following April practically all of the scale on that tree had been consumed and the cage was opened, permitting the beetles to disperse through the orchard. The entire infestation in this orchard was fully controlled by the middle of June. Other heavily infested orchards, each of which received a single colony of beetles, were cleared of the pest within 2 to 4 months. D. W. Coquillett, in charge of the rearing and colonization program, reported under date of October 21, 1889, 10 months after the arrival of the first small consignment in California, that it was difficult to find a living scale in southern California. This was accomplished through a relatively small colonization program, as only 208 colonies, totaling 10,555 beetles, had been distributed up to the middle of June. It is obvious that orchard-wide control was consistently effected within a period of time appreciably less than that represented by three host generations.

The life cycle of *Rodolia* covers about 2 weeks at summer temperatures and the females produce up to 800 eggs each, whereas the host has two and possibly three generations per year.

The mealybugs have long been pests of citrus in California, first the citrus mealybug, *Pseudococcus citri* (Risso) and later the citrophilus mealybug, *P. gahani* Green. The coccinellid predator *Cryptolaemus montrouzieri* Muls. was originally utilized against the citrus mealybug and then against the citrophilus mealybug until supplanted in later years by chalcidoid internal parasites.

Cryptolaemus was introduced into California from Australia in 1891–92. For a time it was reported to be highly effective against the citrus mealybug in the coastal areas but subsided in later years. It was not until the development of mass culture techniques, with field releases each season, that the full potentialities of the species were realized (Smith & Armitage 1931). The course of events under these conditions provides information regarding the time required for control comparable to that from a new introduction, and contributes to the present discussion.

The field releases of *Cryptolaemus* are

made each year, if needed, from the first of April onwards and at the rate of 10 to 20 beetles per tree. Control of the pest is accomplished by the second field generation of larvae, this being 60 to 90 days after the date of release. The longer period mentioned applies to early spring releases. The mealybug hosts average about four generations per year, so that the time required for control is that covered by only two host generations.

The use of *Cryptolaemus* for citrophilus mealybug control was continued for many years, until superseded by internal parasites introduced from Australia in 1928 (Compere & Smith 1932). The principal one of these, *Coccophagus gurneyi* Comp., was first released in the field in southern California in June, 1928, and the entire colonization program was completed by the spring of 1930, at which time the pest was under full commercial control. A marked reduction in the infestations was noted in the spring of 1929 where parasite releases had been made the previous year. No information is available regarding the time required for control in individual groves, but the fact that this was general over the entire infested area within less than two years indicates that control in limited areas had been attained within the three-host-generation period.

Another mealybug pest that has been recently brought under control is the Comstock mealybug, *Pseudococcus comstocki* (Kuw.) that first appeared as a serious pest of apple in the northeastern states during the 1930's. Two internal parasites, *Pseudaphycus malinus* Gahan and *Allotropa burrelli* Mues., were introduced from Japan during the period 1939–41. The colonization program with these and other species covered nearly 10 years but unpublished reports by D. W. Clancy reveal that, in general, the release of these two parasites in infested orchards in the early spring resulted in control by the end of the season. The host has three generations during this period. If the parasites are released upon the second or third brood, rather than the first, control usually is not evident until the end of the following season.

The most recent of the citrus pests of California brought under control by the biological method is the black scale, *Saissetia oleæ* (Bern.). The parasite, *Metaphycus helvolus* (Comp.), was imported from South Africa in 1937. Several instances are recorded (Smith *et al.* 1945) of developments in individual groves following parasite release. One, for example, in which the parasite was first released in November and December 1939, with an additional colonies during the following six months, showed a parasitization of 90 per cent in March, 1941, less than 18 months after the first release. The infestation was rated as light during 1941 and 1942. Later reports revealed many instances in which control was effected in one year, or the time required for only one host generation.

Several factors contribute to rapid control by *Metaphycus helvolus*. Its life cycle is only 2 weeks at summer temperatures, permitting a number of generations each year. The habit of the females of feeding on the body fluids of the young scales, thus causing their death, aids greatly in reducing the scale population.

While *Metaphycus* has been included among the fully effective parasites, yet this degree of effectiveness does not extend throughout the range of its host. Its increase in the interior valleys may be as rapid as in the coastal sections, yet the occasional freezing periods of some winters result in outbreaks of the pest the following season.

Very effective control of the European plum scale, *Lecanium coryli*(L.), was obtained in British Columbia through the introduction of *Blastothrix sericea* Dalm. from England in 1928 and 1929 (Glendenning 1933). Two colonies were released in 1928, but apparently did not become established, while the single one in 1929, flourished and served as a source from which later distributions were made. Field samples taken near the colony site showed parasitization up to 85 per cent one year after release. The entire infested area was under complete control within 3 years. The host insect has only a single generation each year whereas the parasite has two. Average parasitization was 25 per cent in 1930, 60 per cent in 1931 and 99 per cent in 1932, and individual infestations must therefore have been controlled in possibly two host generations.

Two natural enemies of the citrus black fly, *Aleurocanthus woglumi* Ashby, one an internal parasite and the other a predator, that were introduced into Cuba from

Malaya, provide as striking examples of rapidity in control as several of the instances already discussed (Clausen & Berry, 1932).

The parasite, *Eretmocerus serius* Silv., was first released in the field in Cuba in May 1930. A series of test orchards, each of about 10 acres, received one or several colonies of *Eretmocerus*, and developments were closely observed thereafter. All of these orchards were commercially clean in one year or less. Additional observations indicated that a single release of 100 to 500 parasites in a heavily infested 5-acre orchard would consistently bring about control in 8 to 10 months. This period is equivalent to three or at the most four host generations.

The exceedingly rapid rate of increase of *Eretmocerus* results in an average parasitization of 65 to 70 per cent of the pupae in the generation preceding control. The attainment of this population level from such a small initial colony in so short a time is almost unbelievable, when we consider that the host population may exceed one million per tree.

The coccinellid predator, *Catana clauseni* Chapin, which attacks mainly the eggs and first-instar larvae, was likewise imported into Cuba from Malaya in 1930 for control of the citrus black fly. It has proven to be highly effective in reducing heavy initial infestations, but is of little value in maintaining the infestations at a low level thereafter. Its rapid increase and effectiveness in control was demonstrated in an orchard of 2,000 heavily infested trees in which 127 beetles were released in late January and early February, 1931. The entire orchard was commercially clean by the following August, a period representing less than three host generations. The same rapidity in control was observed in other orchards in which colonies were released later. It was estimated that 100 beetles, with a proportionate number of larvae, would be able to effect control of the current host generation on a single tree.

In Hawaii the two most valuable instances of biological control are of the New Guinea sugarcane weevil, *Rhabdoscelus obscurus* (Bdvl.), and the sugarcane leafhopper, *Perkinsiella saccharicida* Kirk. The parasitic fly, *Microceromasia sphenophori* (Vill.), was imported from New Guinea in 1910 for control of the weevil. The first colonies were released in Hawaii in September of that year, and the entire colonization program covered a period of 2 years (Muir & Swezey, 1916). Detailed data are not available regarding the rate of build up of the parasite population and the exact time of the decline of the infestation in specific plantations, though there was a general reduction in borers, with a corresponding increase in yield of cane, during 1913, this being especially noticeable on the plantations that had been most heavily infested and had received the first parasite colonies. The big drop in infestation apparently occurred at the end of 1912, and a further reduction took place the following year. Full effectiveness can be considered as having been attained over the entire area at the end of 1913, or 3 years after the first parasite release.

In this instance, it probably cannot be claimed that full control was attained in any test area within three host generations, as each of these covers only about 4 months, but it certainly came about well within the three-year period.

The sugarcane leafhopper in Hawaii was finally brought under satisfactory control through the introduction of a predaceous mirid bug, *Cyrtorhinus mundulus* (Bredd.), from Fiji and Australia in 1920 (Swezey 1936). Both the nymphs and adults of this bug feed voraciously upon the eggs of the leafhopper. The first field releases, which comprised very small numbers, were made during the summer of 1920. Only a few widely separated recoveries were made during 1921 but the predator was noted to be very abundant on several plantations in March, 1922, and the pest was under full control throughout the islands by the end of that year. This predator appears to have a strong tendency to disperse widely, even at low population levels.

The leafhopper has five or more generations each year and the predator about twice that number. The information available regarding progress in control indicates that this became evident only after approximately 2 years, which is considerably longer than the time required for three host generations.

Some of the most conspicuously successful biological control projects have been in Fiji, and three of these involve pests of coconut. The reports on this work

provide more detailed information on establishment and spread of the introduced natural enemies than is available on other projects and therefore are particularly valuable in their contribution to the present discussion.

The coconut moth, *Levuana irridescens* B.B., was the first of the three problems to be attacked. It is one of the relatively few lepidopterous pests for which full commercial control has been attained by the biological method, and that control was accomplished by a parasite whose normal host is *Artona*, another genus of the family, rather than *Levuana* itself.

This parasitic fly, *Ptychomyia remota* Ald., was imported into Fiji from Malaya in 1925. The first field releases were made in August and September of that year and the entire colonization program, represented by only 38 colonies totaling 32,621 flies, was completed by the following January (Tothill *et al.* 1930). Six months after the initial releases the fly had spread throughout the infested sections and many of the infestations had already subsided completely. Field parasitization in some localities approached 100 per cent. No outbreaks occurred during the following 3 years and it was difficult even to find specimens of the moth. This situation is reminiscent of that which prevailed following the control of the cottony-cushion scale in California.

The attainment of a high population level by *Ptychomyia* in a very short time is possible because of a very short life cycle, requiring a minimum of only 13 days, though the reproduction potential is comparatively low. The host cycle is 40 to 45 days at optimum temperatures.

The coconut scale, *Aspidiotus destructor* Sign., was one of the most destructive pests in Fiji, and has been successfully controlled by a coccinellid beetle, *Cryptognatha nodiceps* Mshll., introduced from Trinidad early in 1928 (Taylor 1935). The first field release was made in March of that year, and a total of 31 colonies, comprising only 5680 individuals, constituted the entire colonization program. This program was completed by the end of September, 1928, thus covering only a 6 months' period. Within 9 months after the arrival of the shipment in Fiji the scale was under control on the most important island, while by September, 1929, it had been completely controlled on every island and it was only with considerable difficulty that clusters of live scale could be found. One infested area on Vanua Levu, comprising a 12-mile coastal strip, with separated patches of coconut interspersed with forest, will serve as an illustration of spread and control. A colony of 500 beetles was released at a middle point of this strip on May 22, 1928 and by March, 1929 they had not only spread over the entire area but had effected complete control. Some portions of the area had been cleaned up considerably before that date. Smaller infestations were consistently brought under control within six months.

The life cycle of *Cryptognatha nodiceps* covers 19 to 25 days from egg to adult and the adults are very long lived. The cycle of the host, from egg to adult, is about 35 days. Considering the size of infestations mentioned by Taylor as being controlled in 6 months it is quite evident that control was accomplished at the localities receiving the colonies well within the time covered by three host generations.

The coconut leaf miner, *Promecotheca reichei* (Baly), was the third in the series of pests in Fiji to be subjugated in a spectacular manner through the introduction of natural enemies (Taylor 1937) The internal parasite, *Pleurotropis parvulus* Ferr., was introduced from Java in 1933 and the first releases were made at the end of May of that year. Developments were followed closely on a number of plantations, one of which may be taken as representative. This area contained 1340 trees which were heavily infested, with an estimated pest population of 4000 per tree, when the parasite colony of about 500 was released on May 26, 1933. By the middle of December virtually 100 per cent of the pupae then present were parasitized, the number being estimated at 4 million. The course of events on other islands was very similar. On one, a circular island with a circumference of about eight miles, the pest was completely suppressed 7 and one half months after the release of a single colony of 600 parasites. In some other localities control was complete within 3 months.

Taylor's concluding statement regarding rapidity of control is as follows: "It was everywhere evident that if the parasites are already present in every tree (even if there is only one per tree) at the

beginning of a generation of the pest, they can entirely suppress it before the end of that generation, and that if they are not uniformly present at the beginning they usually cannot attain 100 per cent parasitism in one generation but can do so in two. On coastal flats, however, provided there are no natural barriers, 100 per cent parasitism can be attained in one generation even though the parasites are not uniformly distributed at the beginning."

The parasite life cycle covers 19 to 21 days whereas the host has three generations and a partial fourth each year.

Mention may also be made here of another coconut leaf miner of a different genus, *Brontispa mariana* Spaeth, that has recently been brought under control in the Mariana Islands. Reports of effective control of other species of *Brontispa* in the Netherlands East Indies and other South Pacific islands by *Tetrastichus brontispae* (Ferr.), which attacks both the larval and pupal stages, led to its introduction from Java into Saipan and Rota early in 1948 (Lange, 1950). Twenty-five colonies of *Tetrastichus* of about 200 each, were released on Saipan and field control was attained in six months. *T. brontispae* has a life cycle of 16 to 20 days, whereas the host may have 3 to 9 generations each year, dependent on climatic conditions.

There are a considerable number of additional instances in which introduced natural enemies have brought about adequate control of their hosts within a very short period of time, not exceeding the three-host-generation or 3-year period, but the published data merely record that this control was accomplished by a given date and do not include information that may be used in a comparative study.

The examples that have been discussed are of parasites and predators that have held their hosts consistently under control year after year. There is another group of species, however, with which rapid and complete control is attained immediately after initial colonization but which decline to a status of only partial effectiveness in later years. This appears to have been the case with the coffee mealybug, *Pseudococcus kenyae* LeP. in Kenya. *Anagyrus kivuensis* Comp. and other parasites were imported from Uganda in 1938. The preliminary report on this project (Le Pelley 1943) gives an account of the early developments. A heavy infestation was completely suppressed within 6 to 8 months after the first release of parasites in 1938. Widespread releases during the following 2 years resulted in satisfactory control on many entire plantations with 6 months to one year of the time of parasite release. Similar control was attained in heavy infestations on native vegetation. In Le Pelley's words "The establishment of the parasites (especially *A. kivuensis*) had a remarkable and extremely rapid influence on the mealybug, the decrease occurring with almost incredible speed and to an almost unbelievable extent on many farms, and similarly in many places in the native reserves." This highly promising beginning, however, was followed by recurrent outbreaks, so that the parasites can now be rated as only partially effective.

Another example of a similar nature is the pupal parasite, *Pteromalus puparum* (L.), which was imported into New Zealand in 1933 for control of the imported cabbage worm, *Pieris rapae* (L.) (Dumbleton 1943). The first releases were made in January to March, 1933. During the latter part of that season it was found that 58 per cent of the pupae in the field were parasitized. Additional releases were made during the 1933–34 season, though obviously they were unnecessary and could not affect the situation. At the end of that season, the parasite had spread at least 80 miles in one direction. In March, 1934, one year after the initial releases, the field parasitization was 89 per cent, at which time the host population had declined so that very few butterflies could be seen in the fields. In other sections, where the parasite had not been released, a very high population persisted. However, the high parasitization declined during the following two seasons and there was a corresponding increase in the host population.

In instances such as the two that have been mentioned, the initial success followed by decreased effectiveness can probably be attributed to one of several causes. The parasite may be able to reduce host infestations of high density but, because of some inherent weakness, cannot hold it at a low level, or the introduction may have taken place by chance during a period in which climatic conditions were exceptionally favorable for the para-

site, but which were not repeated in later years.

The apparently extreme rates of increase that have been cited for a number of successfully introduced parasites and predators are not exceptional, however, and comparable instances can be given for native species when conditions are favorable for them. Everyone is familiar with *Aphidius testaceipes* (Cress.), the braconid parasite of the greenbug and other aphids, which will serve to illustrate this point. This parasite survives the winter in relatively small numbers and reproduces slowly in the spring. However, when summer conditions favorable to it appear, it develops and increases with almost explosive rapidity, and parasitization approaching 100 per cent is often attained within a few weeks.

Even among pest insects the same rapidity in build-up of infestations may be seen. The Japanese beetle increased from only a few hundred individuals in 1916 to millions in 1920, representing only four generations. Outbreaks of forest insects often develop over huge areas with startling rapidity.

The species that are fully effective in the country of origin yet fail to yield an equal degree of control in another country are in a different category. Here, too, the cause of failure is most frequently related to climate, either directly or indirectly. The outcome may extend to complete failures of establishment or establishment at a very low maintenance level. These occurrences are the cause of much disappointment because of the high hopes that are aroused at the time of the importation. Such instances are much more frequent in temperate regions than in the tropics. These are the species which, in the past, we had vainly hoped would adapt themselves to the new environment and in time effect control.

A conspicuous example is *Centeter cinerea* Ald., a larvaevorid parasite of adult Japanese beetles which was found in northern Japan in 1920. (Clausen *et al.* 1927). Each year it consistently destroys 80 per cent or more of the female beetles before they are able to deposit eggs. This high efficiency, in conjunction with the close similarity of climatic conditions in the region of origin with that of the area infested by the beetle in New Jersey, led to high hopes that the solution to the problem had been found. The parasite was imported and first released in 1922 and field recoveries were made the following years. The course of events since that time has been exceedingly disappointing. The response of the parasite to the new environment differed from that of the beetle host. As a result, the majority of the flies emerged far in advance of the beetles and died before hosts were available for oviposition. It was thought that a process of natural selection, whereby each year only the latest emerging flies reproduced themselves, would eventually produce a strain or race in full synchronization with the host. This hope has not been fulfilled. After more than 25 years the seasonal cycle remains the same and the parasite even how is barely able to maintain itself. There is as yet no instance that can be cited to support the belief that an introduced parasite will adapt itself to a new environment and eventually become more effective than in the years immediately following its importation.

CONCLUSIONS. From the evidence that is available from successful biological control projects, we are justified in concluding that natural enemies that are capable of exercising effective control of their hosts will reveal their capacity in this respect very quickly after colonization. In the great majority of past instances of full commercial control, where the detailed history of the project is available, definite control was achieved, *in the vicinity of the colonization points*, within three host generations after release, and in no instance was the time interval longer than three years, even with hosts having an annual cycle. This is equally true of both parasites and predators. Not a single instance is known of an introduced parasite adapting itself to a new environment to the extent of becoming fully and consistently effective after a period of years of comparative ineffectiveness immediately following establishment. No general statement can be made regarding the time required for partially effective species to attain their maximum control status, as this is governed by changing environmental conditions.

The attainment of full control in the minimum period after colonization is no assurance that such effectiveness will be permanent, whereas ineffectiveness during the same period constitutes definite

evidence that the species will never consistently control its host.

If the above conclusions regarding fully effective introduced parasites and predators are accepted, it follows that certain other related conclusions may be drawn, and these have a direct bearing on the conduct of current and future projects.

1. A *fully effective* parasite or predator is always easily and quickly established. This is rather axiomatic, as such a species is perfectly adapted to its host and to the environmental conditions that prevail in its new home. In many instances there is an excellent chance of establishment from the release of a single pair.

2. Failure of a parasite or predator to become established easily and quickly is an indication that it will not be fully effective after establishment is achieved. The difficulties experienced in this regard are a criterion of the future value of the species in control of its host.

3. The colonization of an imported parasite or predator may well be discontinued after 3 years if there is still no evidence of establishment. This is on the assumption that the following requirements have been met; (a) that colonization has been effected in each distinct climatic zone occupied by the host; (b) that the colonies were adequate in size and number; (c) that releases were synchronized with the time of abundance of the preferred host stages: (d) that recovery collections were adequate; and (e) that no biological factor directly affecting continued reproduction is involved (*i.e.* sex differentiation in host relationships, as in *Coccophagus*). This does not imply that establishment might not be attained by further perseverance, but a parasite that requires such efforts will be of little real value and mere establishment will not compensate for the additional cost and labor that are involved.

It is felt that much time and money have been fruitlessly expended in the past in prolonged efforts to establish many parasites and predators. If a species has not become established after the trial period mentioned, there should be no hesitation in discarding it and concentrating upon another of possibly greater value. Similarly, if a species is established but some evidence of control is not forthcoming within that period, it probably never will be attained and colonization aiming at direct control should therefore be discontinued and the program rearranged on a reduced basis, with greater allowance for natural spread to cover the infested area.

LITERATURE CITED

Clausen, C. P. 1939. Some Phases of Biological Control Work Applicable to Sugarcane Insect Problems. Proc. 6th Cong. Int. Sugarcane Tech.: 421–426.

Clausen, C. P. 1941. Some Factors Relating to Colonization, Recovery and Establishment of Insect Parasites. Proc. 6th Pac. Sci. Cong. (1939). **4:** 421–428.

Clausen, C. P., and P. A. Berry. 1932. The Citrus Blackfly in Asia, and the Importation of its Natural Enemies into Tropical America. U.S.D.A. Tech. Bull. **320:** 1–58.

Clausen, C. P., J. L. King, and C. Teranishi. 1927. The Parasites of *Popillia japonica* in Japan and Chosen (Korea) and Their Introduction into the United States. U.S.D.A. Dept. Bull. **1429:** 1–59.

Compere, H., and H. S. Smith. 1932. Control of the Citrophilus Mealybug, *Pseudococcus gahani* by Australian Parasites. Hilgardia **6**(17): 585–618.

Glendenning, R. 1933. A Successful Parasite Introduction into British Columbia. Canad. Ent. **65**(8): 169–171.

Howard, L. O. 1924. Retarded Establishment of Introduced Parasites of Injurious Insects. Proc. Nat. Acad. Sci. USA. **10**(1): 16–18.

Lange, W. H., Jr., 1950. The Biology of the Mariana Coconut Beetle, *Brontispa mariana* Spaeth, on Saipan, and the Introduction of Parasites from Malaya and Java for its Control. Proc. Haw. Ent. Soc. **14**(1): 143–162.

Le Pelley, R. H. 1943. The Biological Control of a Mealybug on Coffee and Other Crops in Kenya. Empire Jour. Exper. Agric. **11**(42): 78–88.

Muggeridge, J. 1943. The White Butterfly (*Pieris rapae* (L)). II. Parasites of the Butterfly. N. Z. Jour. Sci. & Tech. **25.** Sec. 4. No. 1: 1–30.

Muir, F., and O. H. Swezey. 1916. The Cane Borer Beetle in Hawaii and its Control by Natural Enemies. Haw. Sugar Planters' Exp. Sta. Ent. Ser. Bull. **13:** 1–103.

Smith, H. S., and H. M. Armitage. 1931. The Biological Control of Mealybugs Attacking Citrus. Calif. Agr. Exp. Sta. Bull. **509:** 1–74.

Smith, H. S., S. E. Flanders and A. J. Basinger. 1945. The Control of *Saissetia oleae* by *Metaphycus helvolus* (Compere). Calif. Dept. Agric. Mo. Bull. **34**(2): 93–94.

Swezey, O. H. 1936. Biological Control of the Sugarcane Leafhopper in Hawaii. Haw. Sugar Planters' Assoc. Exp. Sta. Ent. Ser. Bull. **21**: 57–101.
Taylor, T. H. C. 1935. The Campaign Against *Aspidiotus destructor* in Fiji. Bull. Ent. Res. **26**: 1–100.
Taylor, T. H. C. 1937. The Biological Control of an Insect in Fiji. An Account of the Coconut Leaf-mining Beetle and its Parasite Complex. Imp. Inst. of Entomology, London, 1–239.
Tothill, J. D., T. H. C. Taylor and R. W. Paine. 1930. The Coconut Moth in Fiji. Imp. Inst. of Entomology, London, 1–269.

Aerial and Ground Application of Insecticides for Pre-Season Control of Alfalfa Weevil[1]

ELLSWORTH HASTINGS and J. H. PEPPER[2], *Montana State College, Agricultural Experiment Station, Bozeman*

The alfalfa weevil, *Hypera postica* Gyll., is a major factor in alfalfa culture in many of the western states. Its ability to establish itself in new territories is evident from a comparison of the distribution maps published by Cook (1925) and Hamlin *et al.* (1949). Since 1940, when the latter distribution map was prepared, this pest has increased its range considerably in Montana and undoubtedly has done so in other areas.

While there are numerous ways in which the activities of alfalfa weevils damage alfalfa crops, the principal damage is caused by the defoliation of the plants by the larvae. Under conditions of heavy larval populations, first cutting alfalfa is extensively damaged. Hamlin *et al.* (1943) describe the typical damage to the first growth.

In addition to the damage referred to above, retardation of the second crop is an important factor in Montana from the standpoint of loss in seed production and in total tonnage of forage. Under certain circumstances, the second crop is held back for 3 weeks or more. This long delay does not afford the seed an opportunity to mature before killing frosts occur nor is there time for a third cutting to be produced.

Ranchers throughout the areas in Montana where alfalfa weevils occur have apparently experienced difficulties in wintering both cattle and sheep on weevil damaged hay. Chemical analyses of extensively damaged and undamaged alfalfa from the same field were made. The samples were collected when the undamaged growth was about half in bloom, and handled in such a manner as to insure a minimum loss of carotene. Nitrogen, phosphorus, and carotene were determined on the two samples. Expressed as a percentage of the dry weight, the protein increased from 14.5 per cent in the undamaged sample to 15.7 per cent in the damaged sample. This increased proportion of protein is not surprising in this case since such a condition is indicative of plants whose normal growth has been inhibited. The phosphorus content was found to be 0.12 per cent in both samples. The carotene content was 79 ppm in damaged alfalfa and 107 ppm in undamaged alfalfa. This corresponds to a 26 per cent reduction due to the activities of the alfalfa weevil. When the normal loss in carotene through harvesting, storage, etc., is considered, this 26 per cent reduction of carotene content may be a significant nutritional factor in wintering livestock.

The control of alfalfa weevils has been obtained by harvesting the first cutting of alfalfa when the damage from larval feeding is still at a minimum. However, recommendations involving early harvesting have not met with any success in Montana because of the reluctance of growers to sacrifice tonnage. The overlapping of the developmental stages of the alfalfa weevil, along with the invulnerability of the egg and pupal stages to insecticidal treatment, present a complex problem in the control of this pest. For example, in Montana the developmental stages overlap approximately as follows: overwintering adults, August 1 to July 1; eggs, April 15 to June 15; larvae, May 15

[1] Contribution from Montana State College, Agricultural Experiment Station Project No. MS-859, Paper No. 238 Journal Series.

[2] ACKNOWLEDGMENT.—The writers wish to acknowledge the assistance obtained from the following industrial concerns who furnished the insecticides, the diesel fuel, the aircraft and pilot, the transportation and loading of the diluent, and the chemical analysis. Without their assistance this work could not have been carried out. Julius Hyman and Company, California Spray Chemical Company, Carter Oil Company, Lynch Flying Service of Billings, Montana, the Fox Oil Company of Hardin, Montana, and the Department of Chemistry Research, Montana Agricultural Experiment Station.

to July 1; pupae, June 10 to August 15; and new adults, July 1 to the end of the season. While the above dates will vary with the season and the locality, they nevertheless serve to illustrate this extensive overlapping. This overlapping has been described by Hagen (1918) and Newton (1933) for Utah and Colorado.

Since the eggs are deposited within the stems of the alfalfa plants and the pupae are in cocoons protected by ground litter, it is impossible to contact them with applications of sprays or dusts. This leaves only two vulnerable stages: the adult and the larval. The extended egg laying period and subsequent larval emergence make it impossible to time a larval treatment when either eggs or pupae, or both, are not present along with the larvae. Partial controls have been obtained by treating the foliage during the larval period. However, extensive damage from larval feeding is always evident in first cutting alfalfa even when a high percentage of the larvae are killed by the treatment. Attempts to prevent a retardation of second growth through treatment of the stubble following the removal of the first crop have not met with success. Therefore, the adult stage between the time of emergence and the beginning of oviposition in the spring, or the adult stage just prior to hibernation in the fall appears to present the best possibilities for insecticidal control. General farming practices of growing alfalfa seed, fall pasturing, or late cuttings preclude a fall treatment as a practical attack.

The control of overwintering adults prior to spring oviposition avoids the many complicating factors referred to above. Preliminary experiments reported by Hastings & Pepper (1949) demonstrated the practicability of such an approach. The results of these experiments show that by employing a pre-season treatment instead of a larval treatment, the excessive damage experienced to first cutting alfalfa and retardation of second cutting growth were avoided.

EXPERIMENTAL PROCEDURE. All insecticidal applications by ground spray equipment were made on ten-acre plots. Adjoining ten-acre plots were used as untreated checks. Where application was made by aircraft, 20-acre plots were utilized which were also adjoined by untreated checks. Due to the uneven distribution of alfalfa weevils throughout the individual fields and the different degrees of infestations between fields, the testing of the insecticides was carried out on rather large plots. This was necessary in order to insure results which could be compared. Ground applications were made using emulsion concentrates at a total volume of eight gallons of water emulsion per acre. The material was applied at approximately 50 pounds pressure with the nozzles 18 inches above the ground surface.

The insecticides applied by aircraft were dissolved in No. 2 diesel fuel and flown on at the rate of 2 gallons total volume per acre. The pilot flew the plane as near the ground surface as the topography of the field would allow. Under most conditions the height did not exceed five feet.

The timing of the spray application may be influenced by the mode of action of the toxicant, the varieties of alfalfa, and the cultural practices of the area. For example, renovation of the meadows before growth starts often retards the appearance of new growth. However, renovation before, during, and immediately after the application of sprays did not appear to influence the results obtained on plots sprayed with dieldrin. The effect of this cultural practice could not be evaluated on the other plots. Treatments were made between April 10 and April 20 (1950) before oviposition was evident. The new growth of alfalfa was approximately 2 inches high in most cases.

As yet no adequate method has been developed for determining comparative adult weevil populations over extensive areas before the alfalfa is six to eight inches high. Therefore, fields which had a past history of extensive weevil damage were selected for the experiments reported herein.

Random samples of adult and larval populations were made by traversing the plots three times (taking 200 sweeps in each plot with a standard 15 inch net). The samples were taken in the same manner in each plot at approximately four and eight weeks after the insecticides were applied.

The following materials were tested by both aerial and ground application methods: benzene hexachloride, aldrin, and dieldrin. Since chlordane had previously been tested using ground equipment, Hastings

Table 1.—Number of alfalfa weevils per 100 sweeps in plots treated with aldrin (aerial application)

Pounds per Acre	Adults		Larvae	
	Treated	Check	Treated	Check
Approximately 4 Weeks After Application				
0.77	0	24	—	—
0.5	0	26	—	—
0.5	0	0	—	—
0.38	4	24	—	—
0.25	2	26	—	—
Approximately 8 Weeks After Application				
0.77	2	37	64	1221
0.5	9	18	404	871
0.5	9	14	97	245
0.38	2	37	181	1221
0.25	41	88	801	3493

Table 2.—Number of alfalfa weevils per 100 sweeps in plots treated with dieldrin (aerial application)

Pounds per Acre	Adults		Larvae	
	Treated	Check	Treated	Check
Approximately 4 Weeks After Application				
0.5	—	—	—	—
0.5	0	0	—	—
0.5	0	12	—	—
0.38	0	24	—	—
0.25	—	—	—	—
0.25	2	24	—	—
Approximately 8 Weeks After Application				
0.5	0	19	13	382
0.5	3	14	79	245
0.5	0	98	75	4646
0.38	1	87	324	1340
0.25	0	12	12	1101
0.25	10	98	203	4646

Table 3.—Number of alfalfa weevils per 100 sweeps in plots treated with benzene hexachloride (aerial application)

Pounds per Acre (Gamma Isomer)	Adults		Larvae	
	Treated	Check	Treated	Check
Approximately 8 Weeks After Application				
0.5	40	77	11	76
0.5	28	88	54	195
0.25	196	248	144	154
0.25	67	48	172	432

& Pepper (1949), only aerial applications of this material were made. The dosages used and the results obtained are recorded in tables 1 to 7.

DISCUSSION. An inspection of the tables will show that in all cases no larvae were present when sweep samples were taken four weeks after the date of treatment.

Table 4.—Number of alfalfa weevils per 100 sweeps in plots treated with Chlordane (aerial application)

Pounds per Acre	Adults		Larvae	
	Treated	Check	Treated	Check
Approximately 8 Weeks After Application				
2.0	3	19	34	382
1.5	9	19	183	382
1.5	15	88	44	195

Table 5.—Number of alfalfa weevils per 100 sweeps in plots treated with benzene hexachloride (ground application)

Pounds per Acre (Gamma Isomer)	Adults		Larvae	
	Treated	Check	Treated	Check
Approximately 4 Weeks After Application				
0.5	0	38	—	—
0.45	12	0	—	—
0.41	12	12	—	—
0.25	18	12	—	—
0.23	2	0	—	—
Approximately 8 Weeks After Application				
0.5	17	70	236	1103
0.45	34	18	682	512
0.41	38	23	37	420
0.25	65	23	944	420
0.23	72	18	752	512

Table 6.—Number of alfalfa weevils per 100 sweeps in plots treated with aldrin (ground application)

Pounds per Acre	Adults		Larvae	
	Treated	Check	Treated	Check
Approximately 4 Weeks After Application				
0.58	4	24	—	—
0.45	0	36	—	—
0.43	0	0	—	—
0.27	18	24	—	—
0.27	0	18	—	—
0.19	4	12	—	—
Approximately 8 Weeks After Application				
0.58	8	76	1005	3039
0.45	7	70	128	1103
0.43	6	18	482	512
0.27	34	27	1484	1151
0.27	15	76	748	3039
0.19	11	42	471	1703

In addition, the data show what might be construed as indicating an increase in adult populations during the interval between the 4 and 8 weeks inspections. The recovery of greater numbers of adults at the later inspection date cannot be attributed to the presence of new adults because only an occasional larva had developed to the cocoon stage by that time.

Table 7.—Number of alfalfa weevils per 100 sweeps in plots treated with dieldrin (ground application)

Pounds per Acre	Adults		Larvae	
	Treated	Check	Treated	Check
Approximately 4 Weeks After Application				
0.51	0	24	—	—
0.44	0	62	—	—
0.42	0	12	—	—
0.28	0	24	—	—
0.26	0	12	—	—
0.26	0	62	—	—
Approximately 8 Weeks After Application				
0.51	0	76	3	3039
0.44	0	98	42	1663
0.42	13	42	400	1703
0.28	0	76	9	3039
0.26	5	42	227	1703
0.26	1	98	115	1663

Migrations were considered as an explanation, but no evidence could be obtained in support of this contention. In fact, the data offer evidence contrary to considering migrations as an explanation. The recovery of adults as shown in table 2 and table 7, where nearly complete control was effected, does not indicate an increase in population. In addition, the borders between treated and untreated areas in which control was obtained remained distinct until the crop was harvested. Extended residual action has also been considered in the case of dieldrin; however, the length of such action was not determined. Similar results regarding adult populations were obtained in cases where chlordane gave effective control. A marked change occurred in the habitat of the alfalfa weevil during the interval between the 4 and 8 weeks sampling. This may have a profound influence on the vertical movements of the weevils resulting in their being more readily captured by sweeping.

The data presented in tables 1 to 7 also show the previously discussed wide variation in the degree of infestations between fields. Many of these fields were either adjoining or in the same area.

A summary of the data presented in tables 1 to 7 is contained in table 8. It will be noted that, regardless of the dosages used, the chemicals are aligned in the following order in respect to their effectiveness: dieldrin, chlordane, aldrin and benzene hexachloride. This order of toxicity is apparent in the reduced numbers of

Table 8.—Average per cent reduction in adult and larval populations of alfalfa weevils in treated over untreated plots as determined eight weeks after insecticide application

Toxicant	Pounds per Acre	Ground Application		Aerial Application	
		Adults	Larvae	Adults	Larvae
BHC (Gamma Isomer)	0.41 to 0.50	20	53	59	8
BHC (Gamma Isomer)	0.23 to 0.25	0	0	11	5
Aldrin	0.50 to 0.77	87	65	44	55
Aldrin	0.19 to 0.38	59	54	66	79
Dieldrin	0.42 to 0.51	94	93	98	97
Dieldrin	0.25 to 0.38	97	94	94	98
Chlordane	1.5	—	—	78	75
Chlordane	2.0	—	—	84	91

both adults and larvae in the treated plots just previous to the first cutting. In fields where 90 per cent or better control was obtained, no observable damage to foliage was noted even upon close inspection. Furthermore, second growth alfalfa was not retarded whereas the check plots which supported heavy larval populations were held back several weeks.

On the basis of the results presented, it appears that dieldrin at a concentration as low as 0.25 pounds per acre when applied at the time and in the manner outlined will effectively control alfalfa weevils by either ground or aircraft application. Chlordane applied at the rate of 2 pounds per acre also proves effective when applied by aircraft. Former tests have shown that chlordane applied by ground equipment will control this pest in pre-season applications of 2 pounds per acre.

SUMMARY. The alfalfa weevil continues to show an ability to adapt itself to new areas. It is an important pest of alfalfa because of its effect on yield, seed production, and nutritional qualities of the forage. The control of alfalfa weevils is complicated by the overlapping of stages in the life cycle, the invulnerability of certain of these stages, and the impracticability of certain cultural practices in various regions. A control method based on the elimination of adult weevils before oviposition starts in the spring appears to offer the best possibilities for success.

Widespread variations were noted in weevil population levels between adjoining fields as well as between fields in different areas. No adult migrations were observed during the spring.

Dieldrin, chlordane, aldrin, and benzene hexachloride were applied as sprays in varying concentrations by ground equip-

ment and by aircraft. These materials were applied at a time when the spring growth of alfalfa was just appearing.

Dieldrin at a concentration as low as 0.25 pounds per acre proved to be an effective insecticide for the control of alfalfa weevils both by aircraft and ground application methods when applied under the conditions of these experiments. Chlordane at 2 pounds per acre was also shown to be effective when applied by aircraft.

LITERATURE CITED

Cook, William C. 1925. The Distribution of the Alfalfa Weevil (*Phytonomus posticus* Gyll.). A Study in Physical Ecology. Jour. Agr. Res. 30(5): 490.

Hagen, Harold R. 1918. The Alfalfa Weevil (*Phytonomus posticus* Fab.). Utah Agr. Col. Expt. Sta. Circ. 31.

Hamlin, J. C., W. C. McDuffee, and F. V. Lieberman. 1943. The Prevention and Control of Alfalfa Weevil Damage. U. S. Dept. Agr. Farm Bul. 1930.

Hamlin, J. C., F. V. Lieberman, R. W. Bunn, W. C. McDuffee, R. C. Newton, and L. J. Jones. 1949. Field Studies of the Alfalfa Weevil and Its Environment. U. S. Dept. Agr. Tech. Bul. 975.

Hastings, Ellsworth, and J. H. Pepper. 1949. Field Tests with New Insecticides for Control of the Alfalfa Weevil. JOUR. ECON. ENT. 42(3): 554.

Newton, J. H. 1933. The Alfalfa Weevil in Colorado. Col. Agr. Expt. Sta. Bul. 399.

Biological Control of Certain Cotton Insects and the Application of New Organic Insecticides in Perú

JOHANNES E. WILLE, *Centro Nacional de Investigación y Experimentación Agrícola de la Molina, Lima, Perú S.A.*

Since 1937, the tobacco budworm or lesser cotton bollworm, *Heliothis virescens* F., has ranked as the most destructive insect enemy of the cotton plant in different cotton valleys of the Central Coast of Perú. Wille (1940) described the history of this insect as a dangerous cotton pest, its development in the years 1937 till 1940 and the different ways to combat the insect. Reports of Marie (1939) traced the general conditions of the *H. virescens* infestation in the Cañete Valley. Hambleton (1944) finally reported, based upon his observations from 1940 to 1943 in the Cañete Valley, all that was known at that time about this dangerous insect, including in his report the historical background, a comparision of the conditions in Brasil and Perú, the development of the *H. virescens* bollworm in the Cañete Valley in the years 1940 to 1943, its ineffective control [incontrollability] by means of various arsenical dusts and the subsequent decline of the *H. virescens* infestation [by the increased activity of its natural enemies and by a more balanced type of agriculture]. Hambleton gave a list of host plants of *H. virescens* in Perú and finished his report with the following forecast:

"The decline in *Heliothis* infestation was attributed to increased activity of its natural enemies. A more balanced type of agriculture, including some rotation of new crops, the planting of corn within cotton fields or adjacent to them, and use of less water in irrigation, all aided in restoring conditions favorable for the propagation of natural enemies and the ultimate decline of *Heliothis*. Cultural control methods thus proved superior and far more economical than chemical control under Cañete conditions. That *Heliothis virescens* would again constitute a menace in the valley does not seem likely unless growers resort to agricultural practices similar to those that are believed to have been largely responsible for the outbreak in the first place."

In the following years till 1946, the balanced rate of the *Heliothis virescens* infestation persisted, not only in the Cañete Valley, but also in the other cotton valleys of the Central Coast of Perú (Chincha, Pisco etc.) and the natural enemies kept down perfectly any increase of *H. virescens*. This situation changed completely in the season 1946–47 for two reasons: the definite abandoning of the flax winter crop and the industrial applications of the new chlorinated insecticides. In the following years, it was observed in industrial fields and in many exact experiments in all cotton valleys of the Central Coast of Perú that DDT, benzene hexachloride, their different mixtures, for instance 3 per cent gamma isomer of benzene hexachloride and 5 per cent of DDT and 40 per cent sulfur ("3-5-40"), and, in lesser degree, toxaphene permitted a heavy increase of *Heliothis virescens* and

other cotton insects because their biological enemies were eliminated.

This observation in Perú coincides perfectly with the report of Rings & Weaver (1948) from Ohio that the parasitism of the oriental fruit moth *Cydia molesta* by the *Macrocentrus* wasps was significantly higher in untreated orchards than in those treated with DDT (5 per cent) dusted 3 to 4 times. They came to the conclusion that DDT did not always give commercial control of *Cydia molesta*, and it seems evident that at certain concentrations the residues may be very toxic to parasites and have little effect on the host.

In December 1949, Newson & Smith reported that the new organic insecticides were interfering with the natural control normally produced by insect enemies of certain cotton pests in Louisiana. They point out that damaging infestations of second generation bollworm, *Heliothis obsoleta*, had developed after dusting of 3-5-40 against the cotton fleahopper. In the same manner severe bollworm infestations developed in one area of 10,000 acres which received three to five applications of either a 20 per cent toxaphene dust or the benzene hexachloride-DDT mixture for boll weevil control. Three series of experiments proved that the new organic insecticides reduced the populations of predators of the cotton aphid, bollworm and spider mites and that they were more detrimental to two predators *Geocoris punctipes* and *Orius insiduosus*, than was calcium arsenate-nicotine.

Out of our numerous field observations in Perú's cotton fields in the seasons 1946 till 1949, we choose only four typical examples: In the Chincha Valley in two successive seasons on an area of 2500 hectares, it was impossible to control the *Heliothis virescens* infestation though DDT or 3-5-40 or toxaphene were applied at different intervals and repetitions. Always, 10 to 15 days after dusting, the number of the *H. virescens* larvae increased again to such an extent that a new insecticide application was necessary. The losses in the harvest amounted, in the first season, to 40 per cent and, in the second, to 60 per cent of a normal yield.

In the Huaura Valley (Huacho) in February of 1949, *Heliothis virescens* appeared suddenly over 300 hectare of late cotton, after this field had been dusted with benzene hexachloride or the "3-5-40" mixture to control the cotton aphid. *H. virescens*, till then, was practically unknown in this part of the valley, but persisted till harvest time and damaged the yield of the later bolls, resulting in a loss of about 20 per cent of a normal harvest.

In the Carabayllo Valley, near Lima, in the season 1948–49 numerous applications of DDT and the 3-5-40 mixture over an area of 3000 hectares, failed completely to control *H. virescens* and the losses were about 50 per cent of a normal harvest so that the farmers searched for another plant to cultivate.

As last example, we mention 400 hectores of cotton fields in the Chincha Valley which had a perfect biological control of *H. virescens*, but in the first days of February 1949, after a thorough dusting with 20 per cent toxaphene, a heavy infestation of *H. virescens* developed, which persisted till harvest time and brought down the yield to only 70 per cent of normal.

The exact observation of these examples and of numerous similar fields demonstrated that the increase of *Heliothis virescens* after dusting with benzene hexachloride, DDT and toxaphene was due to the peculiarity that these organic insecticides killed all the natural enemies of *H. virescens*, and also that the insecticides did not eliminate, to a sufficient degree the *H. virescens* larvae.

To prove this observation by experiments, in the seasons 1947–48 and 1948–49 throughout all the cotton valleys of the Central Coast of Perú, a chain of similar experiments was started. The insecticides used in the tests were: Benzene hexachloride with 2 per cent gamma isomer; mixture "3-5-40"; DDT 5 per cent; toxaphene 20 per cent with 40 per cent sulfur; chlordane 5 per cent; calcium arsenate; special calcium arsenate containing 2 per cent gamma isomer benzene hexachloride; calcium arsenate plus sabadilla[1] (1:1); sabadilla 20 per cent; London purple. The number of applications varied from 2 to 4 per season. The quantity of every application was 25 to 33 lbs per hectare. The results of these tests in all the valleys where *Heliothis virescens* was the most important enemy, gave identical results: the check without any treatment was the healthiest, had the highest yield and all the treatments with insecticides represented economical losses, calculating the costs of the insecticides and their

application against the yield. In the following table we give one typical example (Table 1).

The exact counts of the insect population in the different plots revealed that the natural enemies of *H. virescens* persisted unmolested in the checks and controlled this insect more completely than all the insecticides. The following insects have been observed controlling the *Heliothis virescens*, destroying the eggs, the first instar larvae and sometimes the second instar, in order of their efficacy and frequency:

Paratriphleps laeviusculus Champ., Fam. *Anthocoridae*
Nabis punctipennis Blanch., Fam. *Nabidae*
Hyalochloria denticornis Tsai-Yu Hsiao, Fam. *Miridae*
Parajalysus spinosus Dist., Fam. *Neididae*
Orius tristicolor White., Fam. *Anthocoridae*
Zelus sp., Fam. *Reduviidae*
Scymnus two different species, Fam. *Coccinellidae*
Chrysopa californica Coq., Fam. *Chrysopidae*
Hippodamia convergens Guer., Fam. *Coccinellidae*
Cycloneda sanguinea (L.), Fam. *Coccinellidae.*

The *Paratriphleps*, which is the most important, destroys about 70 per cent and the next four following in the list about 20 per cent of the eggs and new larvae. These five predators are very susceptible to the application of the organic insecticides and are completely eliminated in 24 hours, whereas calcium arsenate and sabadilla did not kill more than 40 to 45 per cent. Therefore, their elimination gives free reign for the increase of *H. virescens.*

On the other hand, of all the modern and old insecticides, only DDT controlled the *Heliothis virescens* larvae, and exact observations in laboratory and field tests revealed that, under the most advantageous conditions, the application of 5 per cent DDT, in 25 to 33 lbs per hectare killed no more than 75 per cent of this larvae in the first to fourth instars. There we have the reason why the DDT and the DDT mixtures failed. We thereby prove that a great difference exists between the North American *H. obsoleta* and the Peruvian *H. virescens* in their susceptibility to the organic insecticide DDT.

The results of the laboratory and field experiments are of great importance in solving the problem of *Heliothis virescens* control in Perú. But it is also necessary to observe the ecological conditions of the cotton culture in Perú. The cotton variety "Tanguis" is a very vigorous plant which under normal conditions, grows to a height of 2 meters and closes in lateral extension between the rows of 1.20 to 1.40 meters so thickly that a human being can not walk between rows without causing damage to the plant. This heavy growth of the Tanguis cotton forms a special microclima in the fields where cotton aphid, leafworm, Peruvian square weevil, *Anthonomus vestitus* Bohm., and *H. virescens*, too, can find good breeding grounds. In the midst of summer, when the water supply is highest, the farmers irrigate too heavily, letting the cotton form big, juicy leaves. *H. virescens* moths prefer these succulent leaves and deposit their eggs on them, being attracted over great distances (about 5 kms) by the humid fields, avoiding the drier plots. So, we have another point for the *H. virescens* control.

The Peruvian cotton growing season begins in September and ends in July. At first, the cotton grows slowly, but from December till March very rapidly. *Heliothis virescens* infestation begins in October and diminishes in May, though about 10 per cent of *H. virescens* larvae remain active in the winter time and about 90 per cent hibernate in the soil as pupae. Therefore, we have in Perú 7 to 8 months where the cotton plant can be attacked by *H. virescens*. The hibernating pupae in the soil begin delivering their moths in October and the hatching continues slowly until January. In consequence, the infestation of the cotton continues constantly and, if the application of DDT begins early in November, it is necessary to continue unalterably till the end of April because DDT kills all the natural enemies and only 75 per cent of *H. virescens* larvae. So, *H. virescens* will complete four to five summer generations without any biological control and without sufficient chemical control as well. Hence it follows that we come up with 20 or more applications of insecticides and the average costs of the insecticides and their applications rises so high that the culture of cotton will result in losses instead of profits.

On reviewing the ecological and biological conditions of the cotton plant in Perú and the resistance of *Heliothis virescens* against the organic insecticides and, on the other hand, the good results of the biological control, after the season of 1948–49, the governmental

Table 1.—The effect of several insecticides upon the control of H. virescens larvae, the yields and the economic losses. Experiment in lattice square, 1947–1948, Hacienda San José, Chincha Valley. Average of four records, rating the 10 best treatments only.

H. virescens Larvae Counted in the Whole Campaign in 100 Terminals or Squares		Yields of Seed Cotton in Pounds per Hectare		Economic Losses in Soles per Hectare, in Comparison with the Checks Without Any Treatment	
Treatment	No. Larvae	Treatment	Yield	Treatment	Loss
Check No. 1	800	Check No. 1	194	Check No. 1	0
Benzene hexachloride, 2% gamma, 2 applications	950	DDT 5%, 2 applications	183	Check No. 2	0
Benzene hexachloride, 2% gamma, 3 applications	990	Check No. 2	179	DDT 5%, 2 applications	222
Sabadilla only, 2 applications	1000	Sabadilla only, 2 applications	167	Sabadilla only, 2 applications	568
Calcium arsenate, 1 application and "3-5-40," 2 applications	1050	Calcium arsenate, 1 application and DDT 5%, 2 applications	147	Calcium arsenate, 1 application and DDT 5%, 2 applications	767
Calcium arsenate plus Sabadilla (1:1), 2 applications	1150	Benzene hexachloride, 2% gamma, 2 applications	130	Calcium arsenate plus Sabadilla (1:1), 2 applications	1062
Special calcium arsenate containing 2% gamma benzene hexachloride, 3 applications	1170	Calcium arsenate plus Sabadilla (1:1), 2 applications	126	Benzene hexachloride, 2% gamma, 2 applications	1076
Check No. 2	1180	Calcium arsenate 2 application and Sabadilla, 1 application	118	Calcium arsenate 2 applications and Sabadilla, 1 application	1187
Calcium arsenate 2 application and Sabadilla, 1 application	1200	"3-5-40," 4 applications	104	Calcium arsenate 2 application and benzene hexachloride, 1 application	1538
Toxaphene 20% plus sulfur, 4 applications	1220	Chlordane 5%, 3 applications	102	Benzene hexachloride 2% gamma, 3 applications	1612

Service of Entomology recommended to the farmers, for the 1949–50 campaign, the artificial increase of the biological control by means of planting corn plants within the new sowing and the one-year ratoon cotton, the least use of water in irrigation possible and the postponement of the application of the organic insecticides against *H. virescens* and the other cotton insects till the last supportable moment.

Our recommendations were exactly executed in six cotton valleys of the Central Coast, whereas two valleys applied the methods of early and numerous insecticidal applications. To demonstrate

Table 2.—Number of insects counted in 100 terminals and 100 squares; average of 300 counts in every observation. Chincha Valley, Hacienda San Pedro, ratoon cotton.

	11.X. 1949	19.X. 1949	18.XI. 1949	14.XII. 1949	28.XII. 1949	4.I. 1950	11.I. 1950
H. virescens eggs	56	30	10	3	5	2	0
H. virescens larvae	48	25	2	1	1	0	0
Paratriphleps young	0	60	200	160	120	100	100
Nabis punctipennis	0	0	3	5	2	1	1
Scymnus spp.	25	17	19	13	10	6	8
Spiders (Lycosidae)	18	20	14	10	2	2	2

Table 3.—Number of insects counted in 100 terminals and 100 squares of cotton and in 100 tassels of corn. Average of 25 fields, 100 counts in every field. Chincha Valley, Hcda. San José. 1949–1950.

Observation of		19.X. 1949	17.XI. 1949	14.XII. 1949	28.XII. 1949	12.I.50		27.I.50			10.II.50		18.II. 1950	4.III. 1950
		Ratoon	Ratoon	Ratoon	Ratoon	Ratoon	First Year	Ratoon	First Year	Heavy Irrig.	First Year	Heavy Irrig.	First Year	First Year
H. virescens eggs	corn	40	30	5	3	0	25	0	20	—	15	—	10	2
	cotton	20	10	15	3	0	14	0	5	30	5	8	2	2
H. virescens larvae	corn	5	2	0	1	1	5	0	1	—	1	—	0	0
	cotton	12	0	0	0	0	1	0	0	8	0	1	0	0
Paratriphleps laeviusculus	corn	200	200	100	50	50	200	100	200	—	200	—	200	200
	cotton	20	300	300	200	100	200	100	200	100	200	200	200	200
Nabis punctipennis	corn	0	5	1	0	—	0	—	2	—	5	—	5	5
	cotton	0	3	10	10	2	10	2	10	2	15	10	15	20
Scymnus spp.	corn	20	20	10	10	—	20	—	20	—	20	—	20	—
	cotton	100	100	140	200	120	100	100	100	200	100	100	100	100
Spiders (Lycosidae etc.)	corn	20	20	20	10	—	10	10	10	—	10	—	10	—
	cotton	40	50	60	60	20	10	10	10	10	10	10	10	—

the course of *H. virescens* infestation in valleys which followed the governmental recommendations, we chose the Chincha Valley, where in the campaign before, the general losses by *H. virescens* had been very heavy; only about 75 per cent of a normal yield was harvested.

In the Chincha Valley, three varieties of corn, early, normal and late, were planted within the cotton rows very early in the season, in the ratoon cotton in August and September and in the new planted cotton ("first year cotton") in September and October. Therefore, in October, many corn plants had developed their tassels. *Heliothis virescens* moths of the first generation deposited eggs in these tassels in preference to the cotton plants. Upon these first eggs began such a rapid increase of the *Paratriphleps*, that at the end of October their numbers was two to three in every tassel. The egg deposits in ratoon cotton increased steadily till the end of November, but these eggs did not hatch equal numbers of larvae, because the *Paratriphleps* and the other natural enemies killed at first few, but later so many eggs and first instar larvae that through November the number of larvae decreased sharply and remained near zero till the end of the campaign. The same was repeated when, in January, the first year cotton became more attractive for the ovipositing moths: first a sharp increase of the number of eggs and larvae, and later a steady but sure reduction till near zero, due to the biological control of the natural enemies. The tables 2 and 3 give two examples, one from the lower part of the valley near the Pacific shore (N° 2), and the other from the upper part between the mountains (N° 3).

Important was the observation that the egg deposits of *Heliothis virescens* persisted through the entire season. Therefore, success of the biological control was dependent upon strict regulation of irrigation of the fields so that succulent growth of the leaves and the stems could be avoided. As mentioned above, these succulent leaves attract *H. virescens* females over wide areas to deposit their eggs causing so great a concentration that natural enemies cannot bring about control of them;

Table 4.—Number of insects counted in 100 terminals in a too heavily irrigated field. Chincha Valley, Hacienda San Antonio, late planted cotton without corn, 1950. After .III. the irrigation was stopped completely.

	18.II. 1950	3.III. 1950	10.III. 1950	17.III. 1950	24.III. 1950	31.III. 1950
Heliothis virescens eggs	40	15	5	3	3	3
H. virescens larvae	10	35	10	3	0	0
Paratriphleps laev.	0	0	5	100	100	100
Nabis punctipennis	0	0	1	5	5	2
Hyalochloria denticornis	6	3	17	50	50	50
Scymnus spp.	10	5	30	50	30	20

and the predators apparently lacking the capacity to work very actively in the humid microclimate of heavily irrigated fields. Two examples are related in tables 3 and 4; in the Hacienda San José (N° 3), only a small field of 7 hectares, without corn plants, was too heavily irrigated in the midst of January and immediately produced a very high infestation (numbers of 27.I.50). But, restricting the irrigation to a minimum, the plants reacted soon and in 15 days the situation was normal again and equal to the other fields. In the Hacienda San Antonio (N° 4) one field of about 30 hectares was sown very late and it was necessary to irrigate abundantly and frequently. So, in middle of February, the infestation by *H. virescens* was high and increased to a dangerous peak in the first days of March with losses of economic importance. Only the complete elimination of irrigation or numerous applications of DDT could save these tardily sown fields. We chose the restriction of water and obtained a very good decrease of the *H. virescens* infestation in 7 days, which continued till the end of the campaign, without any insecticide treatment against *H. virescens*.

The average value of the total harvest in the Chincha Valley for the campaign 1949–50 was a good record, about 20 per cent higher as a normal harvest and 45 per cent better than the crop of the season 1948–49. Important to note, also, is that the farmers did not spend much money (many haciendas nothing) for insecticides, as the natural enemies of *H. virescens* controlled the leafworm and the cotton aphid, also, to sufficient degree.

The example of the Chincha Valley was perfectly corroborated by the other five valleys which used the same method of biological control, obtaining a high yield, 20 to 25 per cent higher then the year bebefore when they used organic insecticides from the beginning of the *H. virescens* infestation. The two other valleys, applying 15 to 20 treatments of organic insecticides against *H. virescens* with an average cost of 1000 to 1300 Soles per hectare, still only harvested a subnormal crop which, added to the high expenses for the insecticides, made the harvest not profitable.

CONCLUSION. In the cotton campaign 1949–50 of six cotton valleys of the Central Coast of Perú, the most dangerous insect, *Heliothis virescens*, was controlled by its natural anemies, in the first place *Paratriphleps laeviusculus*, without applying insecticides against this pest. To obtain this success, it was necessary to restrict the irrigation of the fields with rigorous discipline to avoid a juicy growth of the leaves and stems of the cotton plant. To increase rapidly the number of the natural enemies at the beginning of the season, corn must be planted early within the rows of the cotton fields, equal in ratoon and first year cotton. The harvest of these valleys was about 20 per cent better than a normal yield and 40 per cent higher than the campaign before, where the organic insecticides were applied early in the season. More profitable yet is the fact that practically no money was spent for insecticides against the *Heliothis virescens*.

LITERATURE CITED

Hambleton, Edson J. 1944. *Heliothis virescens* as a pest of cotton, with notes on host plants in Peru. JOUR. ECON. ENT. **37**: 660–666.

Marie, Victor. 1939. El cultivo del algodonero en el valle de Cañete, en relacion con las plagas entomológicas, en 1939. Informe N°. 51, Est. Expt. Agr. La Molina.

Newson, L. D., and C. E. Smith, 1949. Destruction of certain insect predators by applications of insecticides to control cotton pests. JOUR. ECON. ENT. 42, 904–908.

Rings, Roy W., and C. W. Weaver. 1948. Effects of benzene hexachloride and DDT upon parasitization of the oriental fruit moth. JOUR. ECON. ENT. **41**: 566–569.

Wille, J. E., 1940. Observaciones sobre *Heliothis virescens* F. como plaga del algodonero en el Perú. Rev. de Entom. **11**(1-2): 584–588.

Further Studies of Repellents in Alaska[1]

K. H. Applewhite[2] and H. F. Cross,[3] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During the summer of 1949 studies were continued in Alaska on the effectiveness of promising insect repellents against mosquitoes and sand flies. Most of the repellents had been tested previously against arctic species of mosquitoes and black flies at Churchill, Manitoba, Canada, during the summers of 1947 and 1948, and against mosquitoes and sand flies in Alaska during the summer of 1948 (Applewhite *et al.* 1950). The results obtained with the various materials as skin and clothing treatments are discussed in this paper.

Tests Against Mosquitoes.—The tests against adult mosquitoes were conducted in the vicinity of Eielson Air Force Base, Alaska, 30 miles southeast of Fairbanks. The mosquito population consisted largely of *Aëdes excrucians* (Walk.), *A. communis* (Deg.), and *A. pionips* (Dyar), *A. communis* being the predominant species. Mosquito populations during these tests were much higher than during the 1948 season, the biting rates ranging from 20 to 145 per minute as compared with only 15 to 30 in 1948.

Skin Treatments. Thirteen repellents were tested for their effectiveness against mosquitoes when applied to skin. In addition, 11 mixtures were tested, each consisting of 6 parts of dimethyl phthalate, 2 parts of Compound 1[4] and 2 parts of another repellent. All these repellents were diluted to a 25 per cent concentration with ethyl alcohol (95 per cent) to shorten the length of the tests sufficiently to insure their completion before lowered temperatures or increased wind velocity affected mosquito activity. Previous tests conducted by the Orlando, Fla., laboratory had shown that reducing the concentration of repellents did not alter their relative effectiveness, and that the protection time afforded was proportionate to the concentration.

One cubic centimeter of each repellent was applied evenly over the forearm (wrist to elbow) and 1.5 cc. on the leg (ankle to knee) of each test subject. Each repellent was tested twice on each of six subjects and paired once against each other repellent. Protection time was figured to the first bite, provided another bite was received within 30 minutes.

Of the 13 individual repellents tested (Table 1) dimethyl carbate and propyl N,N-diethylsuccinamate gave the longest protection times, the averages being 85 and 101 minutes, respectively. The next best repellent, 2-phenoxyethyl acetate, was effective for 46 minutes. The remaining 10 materials were relatively ineffective with protection times ranging from 3 to 21 minutes. The standard repellents dimethyl phthalate and Repellent 6-12 showed protection times of 19 and 21 minutes, respectively.

Table 1.—Relative effectiveness against Alaskan mosquitoes of various repellents applied to the skin.

Repellent	Minutes to First Bite	
	Range	Average
Propyl N,N-diethylsuccinamate	6–350	101
Dimethyl carbate (dimethyl ester of *cis*-bicyclo[2.2.1]-5-heptene-2,3-dicarboxylic acid)	3–287	85
2-Phenoxyethyl acetate	1–138	46
Repellent 6–12	1–91	21
Cyclohexyl acetoacetate	3–81	21
2,2′-Thiodiethyl diacetate	2–63	20
Dimethyl phthalate	2–76	19
N-*sec*-Butylphthalamide	1–48	11
1,5-Pentanediol dipropionate	5–22	10
Citronella	1–17	9
Compound 1	1–74	9
Ethyl beta-phenylhydracrylate	1–19	6
Diisopropyl tartrate	1–6	3

In the tests of mixtures of repellents (Table 2) the mixture containing dimethyl carbate showed an average protection time of 95 minutes and was distinctly more effective than the others. Mixtures containing Repellent 6–12, N-*sec*-butylphthalamide, cyclohexyl acetoacetate, or propyl N,N-diethylsuccinamate showed about equal effectiveness, with repellent

[1] This work was conducted under funds allotted by the Department of Defense to the Bureau of Entomology and Plant Quarantine.

[2] Captain, on duty with Research and Development Branch, office of the Quartermaster General, U. S. Army.

[3] Now with University System of Georgia, Atlanta Division.

[4] α, α, dimethyl, α carbutoxy, r dihygropyrone (*Indalone*).

times of 57 to 68 minutes. Two other materials were slightly less effective, and four were relatively ineffective. With the exception of the mixture containing dimethyl carbate, none were appreciably better than the one containing Repellent 6-12 (standard 6-2-2 mixture), which was used by the armed forces during the recent war.

Table 2.—Relative effectiveness against Alaskan mosquitoes of mixtures containing dimethyl phthalate, *Indalone*, and another repellent applied to the skin.

Variable in Mixture	Minutes to First Bite	
	Range	Average
Dimethyl carbate	1–251	95
Propyl N,N-diethylsuccinamate	2–219	68
N-*sec*-Butylphthalamide	2–167	62
Cyclohexyl acetoacetate	1–297	61
Repellent 6–12	4–133	57
2-Phenoxyethyl acetate	2–168	49
1,5-Pentanediol dipropionate	5–169	43
Propyl cinnamate	1–109	32
2,2′-Thiodiethyl diacetate	1–139	29
Diisopropyl tartrate	2–72	18
Ethyl beta-phenylhydracrylate	2–47	15

Fabric Treatments. Several series of tests were conducted to determine the immediate effectiveness and durability of different repellents when applied to various types of fabrics and subjected to wearing. Twelve promising repellents previously tested at Orlando were used to impregnate T-shirts and head nets. Four of the most promising repellents were tested further as uniform impregnations.

Cotton T-shirts, rather than closely woven garments, were used in the tests because they offered little mechanical resistance to mosquito bites. Three T-shirts were impregnated with each repellent in emulsion or solution at the rate of 2 grams of repellent per square foot. The emulsion concentrate contained 90 per cent of repellent and 20 per cent of emulsifier[1] (by weight). Each shirt was impregnated with 13.3 cc. of emulsion concentrate in 200 cc. of water, or with 12 cc. of repellent dissolved in 25 cc. of acetone.

The shirts were tested for effectiveness when freshly treated and after several 12-hour periods of wear, mostly at night while the subjects were sleeping. After each period of wear the shirts were tested for 15 mintues (5 minutes by each of 3 test subjects). The treatments were considered ineffective when a total of 15 bites were recorded on the back of the shirt within the 15-minute period, provided the bites were received by at least 2 of the subjects. Shirts not being worn or tested were kept in paper bags.

Of the 12 materials tested (Table 3), 2-[2-(2-ethylhexyloxy)ethoxy]ethanol proved the most durable. Of 3 shirts treated with this material, 2 remained effective after 84 hours of wear. Even then the treated shirts showed about 99 per cent

Table 3.—Relative effectiveness and durability of repellents in cotton T-shirts.

Repellent	Average Number of Bites Received After Indicated Hours of Wear							
	0	12	24	36	48	60	72	84
Acetone solutions								
p-tert-Butylphenol	0	1	6.3	12.3	53[1]	38[2]	—	—
alpha-Butoxy-N-cyclohexyl acetamide	1	0.3	1.6	4.3	6.6	15.3[1]	32[2]	—
Propyl N,N-diethylsuccinamate	0	2.6	5	7	15	16[2]	—	—
Ethyl N,N-diisopropylglutaramate	0	1.3	2	5.6	6.6	24.5[1]	—	—
Cyclohexyl 2-methyl-1,3-dioxolane-2-propionate	0	1	3	16	17.5[1]	60[2]	—	—
Methyl N,N-diisopropyladipamate	1	0	5.6	5.6	9.6	14	32[1]	—
Methyl N,N-dipropyladipamate	1	0	1	2.6	9	14.6	49[2]	—
Ethyl 2-methyl-4-oxo-6-propyl-2-cyclohexene-1-carboxylate	4	16.6	16[1]	26[2]	—	—	—	—
Emulsions								
2-[2-(2-Ethylhexyloxy)ethoxy]ethanol	0	1.6	2	5	6.6	4.3	12	10.5[1]
Compound 1	1	13.3	11.5[1]	15[1]	14[2]	10[2]	24[2]	—
2-Butyl-2-ethyl-1,3-propanediol	7	5	9.3	11[1]	7.5[1]	21[1]	21[2]	—
Hexyl mandelate	4	12.6	24[2]	—	—	—	—	—
Untreated T-shirt	315	300	280	486	590	215	575	675

[1] Only 2 of 3 shirts remained to be tested, since 1 was ineffective at previous test.
[2] Only 1 of 3 shirts remained to be tested, since the other 2 were ineffective at previous tests.

protection when compared with the untreated check shirts. Five other repellents were effective in 2 of 3 shirts after 48 hours of wear, namely: 2-butyl-2-ethyl-1, 3-propanediol, alpha-butoxy-*N*-cyclohexyl acetamide, ethyl N,N-diisopropylglutaramate, methyl N,N-diisopropyladipamate, and methyl N,N-dipropyladipamate.

Regular army-issue cotton herringbone-twill jackets and trousers were used in the uniform impregnation tests. Five uniforms were impregnated with each of four repellents as emulsions at a rate of 75 grams of repellent per uniform, or approximately 2 grams per square foot. All uniforms treated with the same repellent were tested at once for 5 minutes, during which time counts were made of the mosquitoes landing on the back of the jacket and front of one trouser leg. The effectiveness of the repellents was determined by comparing the counts on the treated uniforms with those on the untreated checks. The uniforms were worn by engineer field troops and were collected for testing after 14, 35, and 54 hours of wear.

As shown in table 4, there were considerably fewer landings on treated than on untreated uniforms. None of the repellents, however, prevented annoyance to the troops, as mosquitoes attacked the exposed hands and heads of men wearing treated clothing about as readily as those wearing untreated clothing. Uniforms freshly treated with Compound 1 showed remarkably few landings, but subsequently showed no greater repellency than the other treatments.

Twelve fine-mesh head nets were treated with 25 cc. of a repellent dissolved in enough acetone to wet the net. After drying, the head nets were kept in paper bags until the first test, but thereafter were allowed to age by hanging indoors. Except for the first test, each head net was worn for a total of 15 minutes (5 minutes by each of 3 subjects). Effectiveness was determined by comparing the contacts on the front of the treated nets with the number on untreated nets.

Of the 12 repellents tested (Table 5), Compound 1 was the best from the standpoint of both lowest number of contacts and highest average per cent reduction over check. Isophorone and 2-ethoxyethyl acetate were less effective than the other materials after aging. In general, however, the repellents as a group kept mosquitoes from landing and biting through the head nets for several days.

TESTS AGAINST SAND FLIES.—Tests of repellents against sand flies were conducted in the vicinity of Valdez, Alaska. The predominant species was *Culicoides tristriatulus* Hoffman. As with mosquitoes, the population of sand flies was much higher than during the 1948 season (Applewhite *et al.* 1950).

Skin Treatments. The procedure was the same as that used against mosquitoes, except that the repellent was applied only to the forearm. It was difficult to determine when the sand flies were biting, as they landed freely on treated skin and frequently remained there for some time without biting. At times landings were so numerous that the sand flies caused considerable annoyance merely by crawling on the skin. To be certain that the sand fly was biting, it was necessary to blow gently on it from the back. If the wings were blown upward and the sand fly remained in position, it was considered as biting.

Of the 12 repellents tested (Table 6), dimethyl phthalate was by far the most effective. In one test the treatment was effective for only 11 minutes, but in all others protection times of 41 minutes or more were recorded, with an average of

Table 4.—Relative effectiveness and durability of repellents in cotton herringbone-twill uniforms.

REPELLENT	AVERAGE NUMBER OF LANDINGS AFTER INDICATED HOURS OF WEAR				AVERAGE PER CENT REDUCTION FROM CHECK
	0	14	35	54	
Compound 1	23	180	86	163	80.3
2-[2-(2-Ethylhexyloxy)ethoxy]ethanol	221	117	93	142	79.9
2-Butyl-2-ethyl-1,3-propanediol	222	318	245	195	72.8
Hexyl mandelate	139	115	153	261	60.7
Untreated uniform	1,370	623	440	570	—

Table 5.—Relative effectiveness and durability of repellents in fine-mesh cotton head nets.

Repellent	Contacts after Days of Indoor Aging			Per Cent Reduction from Check
	0[1]	3	5	
Compound 1	1	7	14	95.7
2-[2-(2-Ethylhexyloxy)ethoxy]ethanol	2	8	29	92.3
p-Propoxybenzaldehyde	3	14	23	91.3
2-(2-Butoxyethyoxy)ethyl acetate	2	8	36	90.9
Benzyl ether	9	21	32	83.0
2-Phenoxyethyl acetate	2	22	36	89.1
N-Amylsuccinimide	7	10	17	89.0
N-Butyl-1,2,3,6-tetrahydrophthalamide	5	22	25	90.8
4-*tert*-Amylcyclohexanol	9	18	36	82.8
Cyclopentyl 1-hydroxycyclohexanecarboxylate	11	12	31	82.6
2-Ethoxyethyl acetate	5	37	62	79.0
Isophorone	9	50	87	69.8
Untreated head net	34	264	192	—

[1] Each head net tested on only one subject for 5 minutes.

50+minutes. All other repellents except 2-phenoxyethyl acetate were considered unsatisfactory, with protection times ranging from 8 to 29 minutes.

Fabric Treatments. A few preliminary tests were conducted to compare the repellency of pyrethrun and 2-[2-(2-ethylhexyloxy)ethoxy]ethanol when applied to cotton T-shirts. The shirts were impregnated with 50 cc. of 20 per cent pyrethrum extract or 12 cc. of 2-[2-(2-ethylhexyloxy)ethoxy]ethanol dissolved in enough acetone to wet the shirt. The effectiveness of the treatments was determined by comparing the number of landings on treated and untreated shirts. Pyrethrum caused a reduction in landing rates of only 34 per cent, as compared with 61 per cent for 2-[2-(2-ethylhexyloxy)-ethoxy]ethanol.

SUMMARY.—Studies in Alaska on the effectiveness of repellents against mosquitoes and sand flies were continued in 1949. Dimethyl carbate and propyl N,N-diethyl succinamate were the most effective of 13 materials tested as skin treatments against mosquitoes. Results with 11 mixtures, each containing 6 parts of dimethyl phthalate, 2 parts of Compound 1, and 2 parts of another repellent, showed that the mixture containing dimethyl carbate was superior to the others. Except for this mixture, the one containing Repellent 6-12 (standard 6-2-2 mixture) was about as effective as any other.

Table 6.—Relative effectiveness against Alaskan sand flies of repellents applied to the skin.

Repellent	Minutes to First Bite	
	Range	Average
Dimethyl phthalate	11–90[1]	50
2-Phenoxyethyl acetate	3–61	37
Ethyl beta-phenylhydracrylate	3–54	29
1,5-Pentanediol dipropionate	6–47	21
Cyclohexyl acetoacetate	5–36	19
Propyl N,N-diethylsuccinamate	4–31	18
2,2′-Thiodiethyl diacetate	2–33	15
Repellent 6-12	1–29	14
Dimethyl carbate	3–28	11
Diisopropyl tartrate	1–37	11
Compound 1	2–21	9
N-*sec*-Butylphthalamide	2–32	8

[1] This test was discontinued after the first bite.

In cotton T-shirts 2-[2-(2-ethylhexyloxy)-ethoxy]ethanol was superior to all other repellents. Of 4 repellents tested as uniform impregnations, Compound 1 was the most effective as a fresh treatment but after various periods of wear the treatments showed little difference in effectiveness. The treated uniforms failed to reduce bites on the hands and heads of the wearers. Compound 1 was the most effective of 12 materials tested on head nets.

In tests against sand flies dimethyl phthalate was the most effective material tested for application to the skin. As clothing treatments, neither pyrethrum nor 2-[2-(2-ethylhexyloxy)ethoxy]ethanol was highly effective in reducing landings.

LITERATURE CITED

Applewhite, K. H., and Carroll N. Smith. 1950. Field tests with mosquito and sand fly repellents in Alaska. JOUR. ECON. ENT. 43(3): 353–7.

Insecticidal Effectiveness of Sprays and Aerosols Containing Allethrin

J. H. Fales, R. H. Nelson, R. A. Fulton, and O. F. Bodenstein, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

A number of esters of cyclopentenolones have been synthesized which are related structurally to the cinerins and pyrethrins, the insecticidal principles in pyrethrum flowers (Schechter *et al.* 1949). The first biological test with these synthetic materials (Gersdorff 1949, a, b) were made on house flies by the turntable method. Recently Stoddard & Dove (1949) reported biological results on the completely synthetic allyl homolog of cinerin I against various insects. Piquett (1949) has used the same compound plus synergists in dust tests against American cockroaches. In March 1949 experiments were begun at Beltsville, Md., to determine the effectiveness of this ester when used in sprays and aerosols against house flies, mosquitoes, and cockroaches.

The chemical name of this completely synthetic ester is "*dl*-2-allyl-4-hydroxy-3-methyl-2-cyclopenten-1-one ester with *dl-cistrans*-chrysanthemum monocarboxylic acid." In this paper this ester is called simply "the synthetic ester" but has recently been given the common name allethrin. The material for these experiments was prepared by Bureau chemists. It was tested in various formulations in sprays and aerosols, alone and in combination with other materials. In the spray tests it was compared with the Official Test Insecticide (containing natural pyrethrins), and in the aerosol test with pyrethrum extract containing 20 per cent of pyrethrins.

Tests were also made on the synthetic ester as a substitute for the pyrethrins in several high- and low-pressure aerosol formulations that are in practical use.

The insects included in the tests were the house fly, *Musca domestica* L., the yellow-fever mosquito, *Aëdes aegypti* (L.) the common malaria mosquito, *Anopheles quadrimaculatus* Say, and the American cockroach, *Periplaneta americana* (L.). All the tests were made in a Peet-Grady chamber in the laboratory.

In the house fly tests the sprays were applied by the standard procedure with the standard Peet-Grady equipment, and the aerosols were released from laboratory dispensers as described by McGovran *et al.* (1943) and Goodhue *et al.* (1946).

The tests with mosquitoes were made by a method similar to that described by McGovran & Fales (1944). In both the house fly and mosquito tests free-flying insects were used, and all individuals, whether flying or paralyzed, were collected at the end of the exposure period and held for one day for mortality observations.

In the tests with cockroaches the insects were placed in an open glass-walled pen, 30 inches square, which was set on the floor of the chamber. These insects were exposed to the insecticide for 30 minutes, and mortality counts were made up to the fifth day after treatment.

Comparison of Synthetic Ester with the Natural Pyrethrins.—In tests with house flies direct comparison was made between the synthetic ester and natural pyrethrins in high-pressure aerosols and in sprays. The aerosols contained 89 per cent of Freon-12 as the propellant, 6 per cent of methylene chloride, 4 per cent of deodorized kerosene, and 1 per cent of synthetic ester or pyrethrins. They were applied at a dosage of 4.63 grams per 1000 cubic feet. The sprays contained 1 mg. of the ester or of pyrethrins per milliliter of deodorized kerosene. The testing dosage was 55.56 ml. per 1000 cubic feet. Ten tests were made with the aerosols and 21 with the sprays.

The results of these tests are summar-

Table 1.—Comparison of the synthetic ester and the natural pyrethrins in aerosols and sprays in tests against house flies.

Material	Per Cent Knockdown in—			Per Cent Kill in 1 Day
	5 Minutes	10 Minutes	15 Minutes	
Aerosols				
Synthetic ester	44	69	82	32
Natural pyrethrins	53	73	81	32
Sprays				
Synthetic ester	75	87	—	25
Natural pyrethrins	76	84	—	25

Table 2.—Comparison of the synthetic ester and the natural pyrethrins when used at two dosages in sprays against two species of mosquitoes.

Material	Species	Knockdown in 10 Minutes	Per Cent Kill in 1 Day	
			Males	Females
Series I, 9.26 ml./1000 cu. ft.				
Synthetic ester	*Anopheles quadrimaculatus*	High	65	16
Natural pyrethrins	*Anopheles quadrimaculatus*	Medium	73	43
Series II, 55.56 ml./1000 cu. ft.[1]				
Synthetic ester	*Anopheles quadrimaculatus*	All	100	99
	Aëdes aegypti	All	100	99
Natural pyrethrins	*Anopheles quadrimaculatus*	High	67	38
	Aëdes aegypti	High	82	62

[1] Synthetic ester at 1 mg. per milliliter, natural pyrethrins at 0.2 mg. per milliliter.

ized in table 1. Equal mortalities were obtained for the two materials by each method. In the aerosol the synthetic ester appeared to be somewhat the slower in initial knockdown.

The synthetic ester and the natural pyrethrins were compared in deodorized kerosene sprays against two species of mosquitoes. The results are presented in table 2.

In series I, where 8 tests were run, the low dosage and the concentration of 0.2 mg. per milliliter normally resulted in medium kills of these species. The *Anopheles* mosquito was generally more resistant than the *Aëdes* mosquito. The synthetic ester showed much less toxicity to female *Anopheles* than the natural pyrethrins. Four additional tests were then made (Series II) in which the Peet-Grady fly dosage of only the synthetic ester at a concentration of 1 mg. per milliliter was applied to both species, in order to study further the value of this new compound at a practical dosage. Good results were obtained against both species. The check sprays with the natural pyrethrins spray at 0.2 mg. per milliliter showed that the resistance of the mosquitoes was normal.

Table 3.—Comparison of the synthetic ester and the natural pyrethrins when used in aerosols against the American cockroach.

Material	Stage of Insect	Per Cent Kill in—	
		1 Day	5 Days
Synthetic ester	Adult female	0	0
	Large nymph	0	12
Natural pyrethrins	Adult female	3	42
	Large nymph	2	18

Table 4.—Comparison of the distilled and undistilled synthetic ester and the natural pyrethrins when used in sprays against house flies.

Material	Per Cent Knockdown in—		Per Cent Kill in 1 Day
	5 Minutes	10 Minutes	
Synthetic ester			
Distilled	73	84	22
Undistilled	77	87	24
Natural pyrethrins	73	85	24

Eight tests, in which the aerosols used in the tests against house flies were run against American cockroaches at a dosage of 35 grams per 1000 cubic feet, are summarized in table 3. The synthetic ester showed definite lack of effectiveness against this species at the concentration and dosage used. Natural pyrethrins are not particularly effective at this dosage.

A sample from a lot of the synthetic ester that had been distilled was compared against house flies with a chemically equivalent undistilled sample in deodorized kerosene sprays at 1 mg. per milliliter. The regular Peet-Grady dosage was used and 10 tests were made. The results given

Table 5.—Comparison of aged and freshly made aerosols containing the synthetic ester in tests against house flies.

Age of Aerosol	Per Cent Knockdown in—			Per Cent Kill in 1 Day
	5 Minutes	10 Minutes	15 Minutes	
4 Months	72	83	92	52
Freshly made	58	71	85	53

Table 6.—Effect, in high pressure aerosols, of three commercial synergists on the synthetic ester compared with a nonsynergized formula and a sesame oil-pyrethrins formula. Averages of 4 tests against house flies at a dosage of 4.63 grams per 1000 cubic feet.

Aerosol Formula	Per Cent Concentration	Per Cent Knockdown in—			Per Cent Kill in 1 Day
		5 Min.	10 Min.	15 Min.	
Synthetic ester	0.25				
Piperonyl butoxide	2.0				
Methylated naphthalenes	12.75				
Freon-12	85.0	46	75	85	73
Synthetic ester	0.25				
n-Propyl isome	2.0				
Methylated naphthalenes	12.75				
Freon-12	85.0	45	75	83	80
Synthetic ester	0.25				
Sesame oil extractives	2.0				
Methylated naphthalenes	12.75				
Freon-12	85.0	52	79	90	59
Synthetic ester	0.25				
Deodorized kerosene	2.0				
Methylated naphthalenes	12.75				
Freon-12	85.0	33	58	68	14
Pyrethrum extract (20%)	2.0				
Sesame oil	8.0				
Freon-12	90.0	66	88	91	80

in table 4 show no differences between the samples on the basis of biological results. The undistilled sample was again equal to the natural pyrethrins as was shown in table 1, which indicates that distillation does not improve the synthetic ester.

A sample of the aerosol formulation of the undistilled synthetic ester discussed above and which had been held at room temperature for four months was compared against house flies with a freshly made sample. Two tests at a dosage of 4.63 grams per 1000 cubic feet were made. The resulting data, summarized in table 5, indicate equal effectiveness of the two formulations.

The high-pressure aerosol containing the synthetic ester was used in two tests in which the normal laboratory strain of house flies was compared with a DDT-resistant strain. Less knockdown and kill resulted with the resistant flies at equal dosage.

Effectiveness of the Synthetic Ester in

Table 7.—Effect of substituting the synethtic ester for natural pyrethrins in one of the U. S. Public Health Service aircraft aerosol formulas in tests against house flies and mosquitoes. Averages of 2 tests at 5 grams per 1000 cubic feet.

Aerosol Formula	Per Cent Concentration	House Flies		Mosquitoes[1]		
		Per Cent Knockdown in 15 Min.	Per Cent Kill in 1 Day	Knockdown in 15 Min.	Per Cent Kill in 1 Day	
					Male	Female
Synthetic ester	1.2					
DDT	2					
Methylated naphthalenes	8					
Freon-12	88.8	98	99.5	All	100	100
Pyrethrum ext. (20%)	6					
DDT	2					
Methylated naphthalenes	8					
Freon-12	84	92	98	High	100	100

[1] *Anopheles quadrimaculatus* and *Aëdes aegypti*.

Table 8.—Effect of substituting the synthetic ester for the natural pyrethrins in the Tentative Official Test Aerosol in tests against house flies. Averages of 6 tests at 1.16 grams per 1000 cubic feet.

Aerosol Formula	Per Cent Concentration	Per Cent Knockdown in—			Per Cent Kill in 1 Day
		5 Min.	10 Min.	15 Min.	
Synthetic ester	0.4				
DDT	2				
Methylated naphthalenes	6				
Deodorized kerosene	6.6				
Freon 11 and *12* (1:1)	85	17	36	48	71
Pyrethrum extract (20%)	2				
DDT	2				
Methylated naphthalenes	6				
Deodorized kerosene	5				
Freon 11 and *12* (1:1)	85	15	28	39	72

Practical Aerosol Formulas.—Studies were then made on the effectiveness of the synthetic ester when substituted for pyrethrins in practical aerosol formulas.

A study on the effect of three commercial synergists on the synthetic ester was made in high-pressure formulas against house flies and the results are presented in table 6. Synergism was apparent in all three mixtures, although in one case there was marked recovery of paralyzed flies.

Tests were made on the substitution of the synthetic ester for the pyrethrins in one of the U. S. Public Health Service formulas approved for use on airplanes, and the results are summarized in table 7. The formula containing the synthetic ester appeared equal to the approved natural pyrethrins formula against both house flies and mosquitoes.

The previously discussed aerosol tests were all made with high-pressure, Freon-12 propelled formulas. Work was also done with the synthetic ester in low-pressure (37 p.s.i.) formulas in which a mixture of *Freon 11* and *12* (1:1) was used as the propellant.

The synthetic ester was compared with the natural pyrethrins as used in the Tentative Official Test Aerosol of the Chemical Specialties Manufacturers' Association,[1] and the results are presented in table 8. The synthetic ester formula was equal to the T.O.T.A. in the kill produced and somewhat better in knockdown effect.

Three low-pressure aerosol formulas which contained DDT and a synergist in addition to pyrethrins were selected and made up with the synthetic ester and also with pyrethrum extract. The six formulations were tested against house flies and the results are presented in table 9. The T.O.T.A. formulation was included for general comparison. The formulas containing *n*-propyl isome gave similar results. The Van Dyk 264 formula containing the synthetic ester caused higher mortality than the corresponding formula containing pyrethrins. The knockdown was nearly equal. The mortalities with the piperonyl butoxide formulas matched, but the knockdown with the formula containing the synthetic ester was considerably lower.

Summary.—The biological results presented herein show that the completely synthetic allyl homolog of cinerin I compares favorably with the natural pyrethrins when tried in kerosene-base sprays against house flies, *Musca domestica* L. In aerosols the synthetic ester is also shown to give results similar to the pyrethrins against this insect. At low concentrations against mosquitoes the synthetic ester was less toxic than the pyrethrins. Increased dosages resulted in satisfactory performance.

In aerosol tests against American cockroaches, *Periplaneta americana* (L.), the synthetic ester was much inferior to the natural pyrethrins, although the latter were not very effective at the concentrations tested.

Distillation of the synthetic ester did not change the effectiveness of this ester against house flies. Storage of aerosol formulas containing this ester resulted in no change in effectiveness. DDT-resistant house flies showed some resistance to the synthetic ester.

[1] T.O.T.A.

Table 9.—**Effect of substituting the synthetic ester for the natural pyrethrins in various low-pressure aerosols containing synergists, in tests against house flies. Averages of 6 tests at 1.16 grams per 1000 cubic feet.**

AEROSOL FORMULA	PER CENT CONCENTRATION	PER CENT KNOCKDOWN IN—			PER CENT KILL IN 1 DAY
		5 Min.	10 Min.	15 Min.	
Pyrethrum extract (20%)	1				
n-Propyl isome	2				
DDT	2				
Methylated naphthalenes	5				
Deodorized kerosene	5				
Freon 11 and *12* (1:1)	85	9	22	37	73
Synthetic ester	0.2				
n-Propyl isome	2				
DDT	2				
Methylated naphthalenes	5				
Deodorized kerosene	5.8				
Freon 11 and *12* (1:1)	85	6	19	33	70
Pyrethrum extract (20%)	1				
Van Dyke 264	2				
DDT	2				
Methylated naphthalenes	5				
Deodorized kerosene	5				
Freon 11 and 12 (1:1)	85	10	27	35	69
Synthetic ester	0.2				
Van Dyk 264	2				
DDT	2				
Methylated naphthalenes	5				
Deodorized kerosene	5.8				
Freon 11 and *12* (1:1)	85	9	25	39	77
Pyrethrum extract (20%)	1				
Piperonyl butoxide	2				
DDT	2				
Methylated naphthalenes	5				
Deodorized kerosene	5				
Freon 11 and *12* (1:1)	85	26	56	68	85
Synthetic ester	0.2				
Piperonyl butoxide	2				
DDT	2				
Methylated naphthalenes	5				
Deodorized kerosene	5.8				
Freon 11 and *12* (1:1)	85	13	34	53	83
Pyrethrum extract (20%)	2				
DDT	2				
Methylated naphthalenes	6				
Deodorized kerosene	5				
Freon 11 and *12* (1:1)	85	16	32	43	80

In tests with high-pressure aerosols against house flies piperonyl butoxide, *n*-propyl isome, and sesame oil extractives all showed synergism with the synthetic ester. There was considerable recovery of flies knocked down with the sesame oil extractives formulation.

The formulas containing *n*-propyl isome acted similarly with the synthetic and with natural pyrethrins. The Van Dyk 264 formulas appeared to give slightly better kill, when the synthetic ester was used. The knockdown was lower, but the mortality was the same, when piperonyl butoxide was used with the synthetic ester.

The synthetic ester was equal to the natural pyrethrins in one of the U. S. Public Health Service aerosols and also in the Tentative Official Test Aerosol formulation when tested against house flies.

LITERATURE CITED

Gersdorff, W. A. 1949 (a). The toxicity to house flies of some synthetic compounds of the pyrethrin type in relation to chemical structure. JOUR. ECON. ENT. **42**(3): 532–7.

Gersdorff, W. A. 1949 (b). Toxicity to house flies of new synthetic pyrethroid. Soap and Sanit. Chem. **25**(11): 129, 131, 139.

Goodhue, L. D., W. R. Ballinger, and J. H. Fales. 1946. Improved dispenser for testing new liquefied-gas aerosols. JOUR. ECON. ENT. **38**(6): 709–10.

McGovran, E. R., and J. H. Fales. 1944. Activated pyrethrum mosquito spray. Soap and Sanit. Chem. **20**(2): 117, 119.

McGovran, E. R., J. H. Fales, and L. D. Goodhue. 1943. Testing aerosols against house flies. Soap and Sanit. Chem. **19**(9): 99, 101, 103, 105, 107.

Piquett, P. G. 1949. The effect of four commonly used synergists on a synthetic pyrethroid. JOUR. ECON. ENT. **42**(5): 841–2.

Schechter, M. S., Nathan Green, and F. B. LaForge. 1949. Constituents of pyrethrum flowers. XXIII. Cinerolone and the synthesis of related cyclopentenolones. Jour. Amer. Chem. Soc. **71**: 3165–73.

Stoddard, R. B., and W. E. Dove. 1949. Cinerin I homolog tested. Soap and Sanit. Chem. **25**(10): 118–121, 161.

The Apple Flea Weevil[1]

F. G. MUNDINGER, *New York State Agricultural Experiment Station, Geneva*

Experimental work on the apple flea weevil. *Rhynchaenus pallicornis*[2] Say, was begun in 1937 when a heavy infestation was reported in a planting south of Syracuse, New York. Observation and experimentation were carried on during the following ten years but were not continuous.

In New York the weevil is a localized pest; infestations are known to exist only in the vicinity of Syracuse, near Schenectady and at Nassau in Rennselaer County. The adult is a rather shiny, black curculio about 3 mm. long, having a well-developed proboscis and strong, jumping hind legs (Fig. 1, 1). The weevils overwinter in sod or under leaves and debris, commonly close to the trunks of the host trees, but they may also be found along hedge rows and in other locations at varying distances from the orchard.

With the advent of warm weather, usually during the month of April, the beetles leave their winter quarters and go up into the trees. At this time some varieties of apples may be in the "delayed dormant" bud stage. The insects begin to feed at once, commonly on the buds or on the under surfaces of the leaves. After a short time mating takes place and soon oviposition begins. The whitish ellipsoidal eggs (Fig. 1, 2) are placed usually in the midribs on the lower leaf surface, but eggs have also been found in the smaller veins and occasionally in the leaf tissue. From one to several eggs may be laid in a single leaf. In preparation for oviposition the female makes an excavation with her mandibles sufficiently large to accommodate the egg, and after deposition the opening of the cavity is plugged with excrement, The location of the egg can easily be determined by the brownish oviposition wound and the accompanying swelling. After hatching, the larva (Fig 1, 4) bores through that portion of the vein wall between the two leaf surfaces and continues on toward the edge of the leaf confining its burrow to the area between two larger veins. The tunnel (Fig. 1, 3) is at first very narrow but widens gradually until it reaches a point near the distal end. Here it is abruptly expanded into a large, somewhat triangular area which eventually becomes blister-like in appearance. In this chamber the larva constructs a hard pupal case in which it transforms to an adult. The pupation period is about a week after which the weevil emerges through a hole made in the leaf tissue. The time between hatching and the emergence of the adult is about 18 days, although in some cases it was found to be considerably longer. The weevils feed on the foliage until July or August when they gradually become scarce, most of them going into hibernation before September 1. The maximum length of time that overwintering adults lived after emerging from hibernation, as determined by cage studies, was 48 days.

Flea weevils are injurious in several

[1] Journal Paper No. 844, New York State Agricultural Experiment Station, Geneva, N. Y., November 9, 1950.

[2] Formerly *Orchestes pallicornis*.

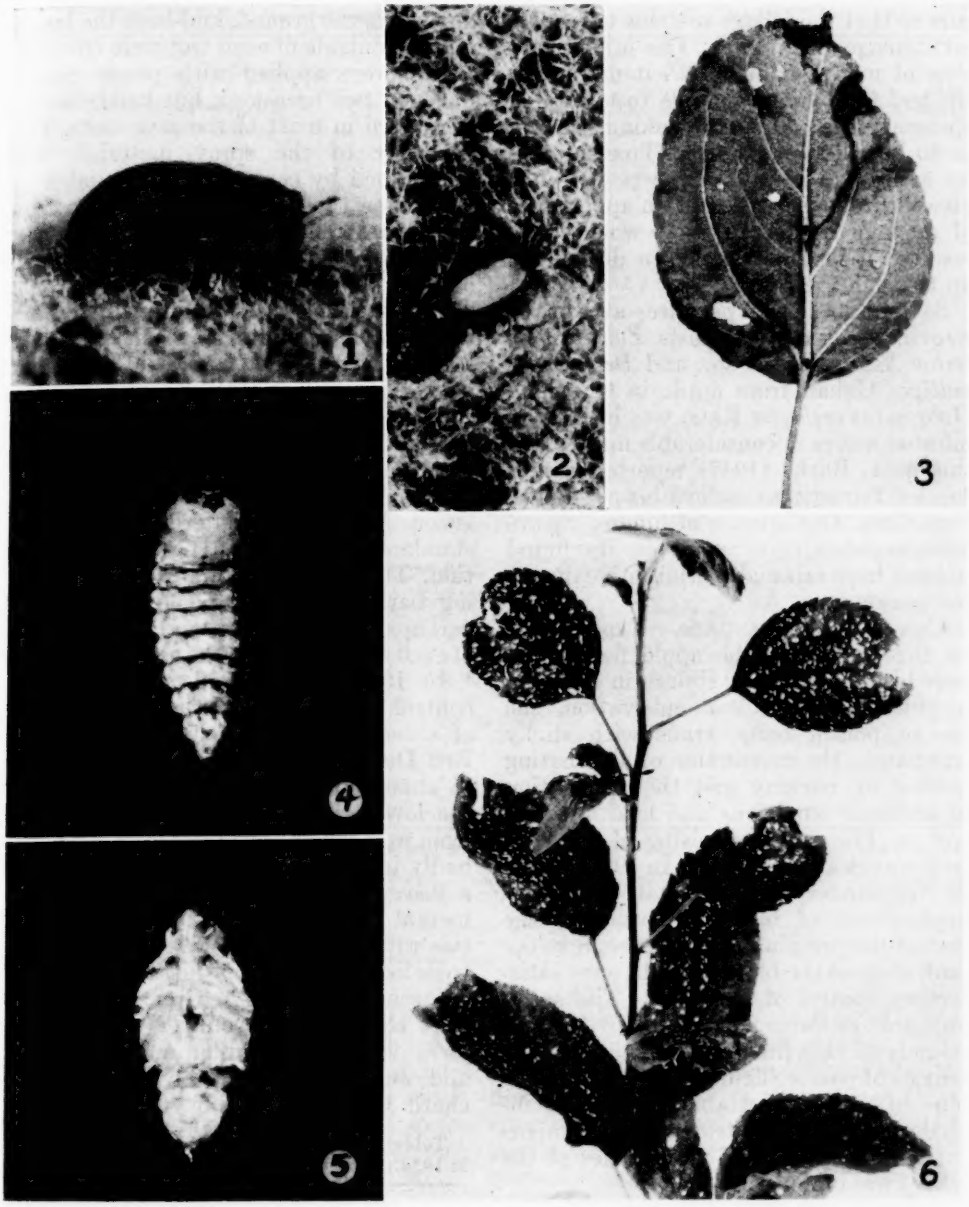


FIG. 1. THE APPLE FLEA WEEVIL

Showing stages of *Rhynchaenus pallicornis* Say and injured foliage. 1. Adult; 2 Egg; 4 Larva; 5. Pupa, all ×15. 3. Apple leaf showing mines and egg punctures in the mid rib; 6. Feeding punctures made by adults.

ways: (1) The adults may injure or kill the unopened buds; (2) they may damage the leaves severely; (3) the larvae weaken or impair leaf function by mining between the two leaf surfaces.

During seasons favoring an early emergence of the flea weevil but late development of the leaves the insect attacks the buds, drilling deep holes into them by means of its long proboscis, and, as a result, the immature flower structures are severely damaged or destroyed. Normally in this region of the state the leaves begin to unfold before much feeding oc-

curs so that the foliage sustains the greatest damage (Fig. 1, 6). The injury consists of many small holes eaten through the leaf from the lower side to the upper epidermis, one individual making as many as 20 holes in a single day. Trees injured by a heavy infestation of weevils when viewed from below present an appearance of damage similar to what would have resulted if birdshot had been discharged up through the foliage.

Several species of parasites attack the weevil. Houser (1923) lists *Zatropis incertus* Ashm., *Epius* sp., and *Derosternus pallipes* Gahan from apple in Ohio and *Habrocytus orchestis* Ratz. was bred from infested leaves in considerable numbers in this area. Burks (1943) reported a new species *Tetrastichus malophilus* n. sp. also from Ohio. One species of fungus, *Sporotrichum globuliferum* Speg., was also found to have been especially destructive during wet seasons.

CONTROL MEASURES.—Experiments on the control of the apple flea weevil were begun in Ohio by Houser in 1915 and included tests of clean cultivation, the use of poison baits, trials with sticky tree bands, the destruction of hibernating beetles by burning and the application of kerosene emulsions and lead arsenate sprays. The most promising of the controls was clean cultivation. In 1936 Houser & Neiswander reported that two spray applications of barium fluosilicate, the first at the pre-pink and the second at the pink stage of the blossom buds, gave satisfactory control of the insect. The spray mixture recommended consisted of 5 pounds of this fluorine compound and 4 ounces of *goulac* (lignin pitch) in 100 gallons of water. Wettable sulfur was included for scab control and the importance of spraying the under sides of the leaves was emphasized.

Using the above experience as a guide, most of the spray applications that were applied in the tests to be reported here were made during the pre-blossom period. All of the tests except those of 1946 were made with the help and the equipment of interested growers, and the timing of the applications was adapted to fit into their working programs. The power sprayers used maintained pressures ranging from 600 to 800 pounds and in some cases were equipped with brooms instead of the conventional spray guns. All spraying was done from the ground, and both the inside and the outside of each tree were covered. Dusts were applied with power equipment on two occasions, but hand dusters were used in most of the cage tests. The efficiency of the spray materials was determined by comparing the number of weevils on the treated trees with that on the nearest check trees, one or more of which were left near the center of each outside row of the experimental area. To avoid the effects of spray drift and the possible reinfestation from the check trees, only the center trees in each plot were examined and all the weevils that could be identified from the ground were counted. In evaluating the results the total number recorded for each tree was used to represent the relative tree population. Most of the materials tested were standard products and need no description. The fluorine compositions containing barium fluosilicate and cryolite are perhaps an exception, and the analysis of each is given in the footnotes to table 2.

In 1937 four orchards were used for control experiments. Orchard 1 consisted of several varieties including McIntosh, Red Delicious and Spy, set in four rows of about 30 trees each, extending along the lower side of a slope well protected from west winds. The trees were large and badly in need of trimming and contained a heavy weevil infestation. The experimental plots in orchard 2 consisted of two rows of large but well cared-for Spy trees located higher on the same slope and adjacent to orchard 1. Orchards 3 and 4 were comprised of younger trees of uniform varieties standing on flat terrain and were only moderately infested. Orchard 1 was divided into 6 narrow plots

Table 1.—Emergence of the apple flea weevil in 1938.

DATE	NO. OF APPLE FLEA WEEVILS
April 21[1]	157
April 23	1
April 24	2
April 26	68
April 29	3
May 3	6
May 4	8
May 6	8
May 11	4
May 17	4
May 18	0

[1] Cages damaged by a severe wind storm and reset April 14.

Table 2.—Results of sprays for the control of the apple flea weevil.

MATERIAL USED PER 100 GALLONS SPRAY[1,2]	ORCHARD NO.	DATES SPRAYED	TREES EXAMINED	WEEVILS ON TREATED TREES	WEEVILS ON UNTREATED TREES	PER CENT CONTROL
		Tests in 1937				
Fluorine Comp. 1,[3] 3 lbs.; bentonite, 4 lbs.	1	5/5, 5/13	16	65.8	119.8	46.1
Lime-sulfur 1-40; lead arsenate, 6 lbs; lime, 3 lbs.	1	5/5, 5/13	22	99.0	150.1	37.0
Lead arsenate, 6 lbs.; bentonite, 4 lbs.	1	5/5, 5/13	17	90.9	122.1	26.3
Lead arsenate, 6 lbs.; bentonite, 4 lbs.	2	5/31	11	54.8	128.0	57.2
Fluorine Comp. 1,[3] 3 lbs.; goulac, 4 ozs.[4]	2	5/31	10	60.2	128.0	53.0
Fluorine Comp. 2,[5] 5 lbs.; goulac, 3 ozs.	5	5/13	70	1.5	4.5	66.7
Fluorine Comp. 2, 5 lbs.; goulac, 3 ozs.	3	5/13	11	5.4	13.0	58.5
		Tests in 1938				
Fluorine Comp. 2,[5] 5 lbs.; goulac, 3 ozs.	1	4/23, 4/29	18	1.3	11.1	87.4
Fluorine Comp. 1,[3] 5 lbs.; goulac, 3 ozs.	1	4/23, 4/29	20	1.0	7.7	84.8
Lead arsenate, 5 lbs.; summer oil, 1 pt.	1	4/23, 4/29	20	7.9	11.1	28.4
Ground derris root,[6] 4 lbs.; Grasselli spreader, 1 pt.	5	4/26	26	6.3	33.8	81.4
Fluorine Comp. 3,[7] 5 lbs.; goulac, 3 ozs.	5	4/26	25	3.6	18.7	80.7
Ground derris root, 4 lbs.; Grasselli spreader, 1 pt.	6	4/26	17	4.8	13.5	64.4
Lead arsenate, 6 lbs.; Orthex, 1 pt.[8]	6	4/26	17	7.4	13.5	45.2
Lead arsenate, 3 lbs.; Orthex, 1 pt.	6	4/26	9	13.8	13.5	0.0
		Tests in 1946				
DDT 50%, 2 lbs.	7	4/19, 4/30	9	3.8	204.1	99.8
DDT 50%, 1 lb.	7	4/19, 4/30	10	6.1	421.6	97.6
Fluorine Comp. 2,[5] 5 lbs.	7	4/19, 4/30	8	7.0	284.0	92.7
DDT 50%, 1 lb.	7	4/30	4	62.8	493.0	87.3
Fluorine Comp. 2,[5] 5 lbs.	7	4/30	4	89.5	493.0	81.3
		Tests in 1948				
Parathion 25%, 3/4 lb.	8	7/8	6	1.5	105.0	98.6
DDT 50%, 2 lbs.	8	7/8	6	1.7	130.0	97.5
BHC, 6% gamma isomer, 2 lbs.	8	7/8	5	2.5	73.3	96.6
Ground derris root, 5 lbs.	8	7/8	6	9.5	63.1	83.5

[1] In all sprays except those of 1948, and in mixtures containing lime-sulfur, from 8 to 10 pounds of wettable sulfur were included for protection against scab.
[2] In 1946 and 1948, 1 pint of summer oil emulsified with a small amount of water was used as a spreader and sticker in all mixtures.
[3] Barium fluosilicate 72%, sodium fluoaluminate 8% and inert 20%.
[4] Lignin pitch.
[5] Sodium fluoaluminate 90%, inert 10%. (Kryocide) Pennsylvania Salt Mfg. Co., Philadelphia, Pennsylvania.
[6] Sodium fluoaluminate 83%, inert not more than 17%. (Alorco) Aluminum Co. of America, Pittsburgh, Pennsylvania.
[7] Grasselli spreader-sticker, E. I. duPont de Nemours & Co., Inc.
[8] Spreader-sticker, California Spray Chemical Corp.

arranged in two series running lengthwise of the planting and contained 16 trees each. To compensate in part for differences in infestation the treatments were duplicated. The first applications were made as the buds of an occasional blossom cluster of the McIntosh variety were beginning to separate, at which time weevils could be readily observed feeding on the young leaves. The second treatment was applied at the late pink bud stage, and by this time the weevil population appeared to have increased noticeably. Drenching rains followed both sprays. The plots in orchards 2, 3 and 4 were not duplicated, and only one treatment was made in each. The results obtained in the tests are given in table 2, along with data of succeeding years.

In 1938, orchard 1 was used again. It was divided into three duplicated plots extending crosswise of the planting. This orchard had been previously sprayed with dormant materials to determine their effectiveness, if any, on the hibernating adults. Orchard 5 consisted of about 15 rows of large, dense trees partly protected on the north and east by adjoining orchards. Four rows of trees extending through a low area near the center were divided into two plots, each of which received one application. Orchard 6 consisted of well trimmed young trees standing on open terrain. It had been sprayed with lead arsenate earlier in the season but for the present tests, it was divided into three duplicated plots each of which received a single spray. The heaviest infestation occurred in orchard 5, but it did not approach the severity of the 1937

infestation in orchard 1 where over 17,000 weevils were counted in 2 hours by four observers with no intent of setting a record. In order to find the correlation between bud development and the appearance of the weevils, three large emergence cages were set in the orchard. The data obtained on emergence are shown in table 1. The timing of the treatments corresponded fairly well with the pre-pink and pink stages of the blossom buds and with the presence of weevils in maximum numbers.

In 1946 a portion of orchard 7, composed of large trees standing in a location well protected by near-by hills and adjoining orchards, was divided into three duplicated plots of 15 trees each and received two applications of spray. In addition, two plots toward the north were sprayed once. DDT was used in these tests for the first time, and conditions for applying the sprays were optimum. The applications were correlated as closely as possible with the pre-pink and pink stages of the blossom buds, and beetles were observed feeding at the time of both treatments.

During the summer of 1948 an opportunity was afforded to test the efficiency of parathion, benzene hexachloride, DDT and ground derris root on the weevil. The experimental orchard which was moderately infested consisted of fairly large trees located on a gentle slope and protected on the west by a high hill. It was divided into four duplicated plots of about nine trees each, and, since only a few check trees could be left for a limited time, population counts were made in each plot before and after spraying, with the exception of one DDT plot, and the per cent control was derived from these data.

Experiments were carried on in 1940 and 1941 with pyrethrum, rotenone and nicotine dusts. While a few of the tests were made during the pink stage of the blossom buds when temperatures were comparatively low, most of the work was done in midsummer when beetles of the new brood were plentiful. In the first series of tests with power equipment, about 200 of the dislodged weevils from each plot were transferred to cages containing clean foliage, and observations were made on their survival. A second series of dusts was applied with hand dusters to caged weevils while in a third test only the foliage was dusted and untreated weevils introduced. Usually 50 weevils were used in each of the latter tests. The results are shown in table 3.

DISCUSSION.—It will be noted from a study of table 2 that the results in 1937 with all materials were relatively poor. In orchard 1, the severity of the infestation and the difficulty of making a thorough cover should be considered in interpreting the data. It will be seen that the greatest reduction in weevil population was obtained in orchards 2, 3 and 4 where the trees were open and could be more thoroughly sprayed. Fluorine composition 2 used at the rate of 6 pounds in 100 gallons in orchard 1 was the most effective mixture but gave only 66.7 per cent control. The results, however, indicated the probability of control with two sprays at this concentration. Lead arsenate used in orchard 2 at 6 pounds in 100 gallons gave the highest reduction secured at any time by this material, but its effectiveness in orchard 1 was not promising. No foliage injury was observed along the borders of adjoining plots where mixtures of fluorine and lead arsenate sprays

Table 3.—Results of tests with insecticidal dust formulations in 1940 and 1941.

MATERIAL	POWER OR HAND DUSTER	RECORD TAKEN HOURS AFTER TREATMENT	PER CENT DEAD	PER CENT DEAD IN CONTROLS
		1940 Tests 7/25		
Cube root dust 1.5% rotenone	power	48	99.5	27.0
Cube root dust 1.5% rotenone	power	29	96.5	0.0
Cube root dust 1% rotenone	power	48	95.5	27.0
Cube root dust 1% rotenone	power	29	91.5	0.0
Pyrethrum dust[1] .2% pyrethrins	power	29	95.0	0.0
Pyrethrum dust[1] .2% pyrethrins	power	48	95.0	27.0
		1941 Tests 7/27		
Pyrethrum dust .35% pyrethrins	power	30	100.0	0.0
Pyrethrum dust[1] .2% pyrethrins	power	30	94.0	0.0
Cube root dust[2] 1.5% rotenone	Hand	48	100.0	15.0
Cube root dust[2] 1.5% rotenone	Hand	48	36.0	15.0
Cube root dust[2] 1% rotenone	Hand	48	100.0	15.0
Cube root dust[2] 1% rotenone	Hand	48	30.0	15.0
Pyrethrum dust[1,2] .2% pyrethrins	Hand	48	96.0	15.0
Pyrethrum dust[2] .2% pyrethrins	Hand	48	12.0	15.0

[1] Commercial mixture prepared from a standardized pyrethrum extract impregnanted on an inert filler.
[2] Both insects and plants dusted.
[3] Only plants dusted.

occurred on the leaves. In 1938 the results with fluorine compositions 1 and 2 in orchard 1 were very encouraging giving reductions of 84.8 and 87.4 respectively. Lead arsenate, it will be noted, was again the least effective of the materials used. Both fluorine compound 3 and ground derris root applied once under the difficult conditions of orchard 5 showed fair results. None of the treatments in orchard 6 appeared to be very effective, the lead arsenate sprays especially giving poor results. The duplicated treatments applied at the dormant period in 1938 had no appreciable effect on the weevil. In 1946 both DDT sprays and fluorine compositions produced excellent results in orchard 7 which was heavily infested. Reductions of 99.8 and 92.7 respectively were obtained by two applications at the maximum dosages shown in the table; however, DDT at 0.5 pound (actual) was about as effective as at one pound, giving 97.6 per cent reduction. It will be noted also that one application of the material at the same lighter dilution gave a fairly high reduction. Fluorine compound 2 applied once was the least effective but provided good protection against the weevil. In tests made during the summer of 1948, parathion, benzene hexachloride and DDT were very effective, giving reductions of 98.6, 97.5 and 96.6 per cent respectively.

The pyrethrum and rotenone dusts applied in 1940 and 1941 dislodged large numbers of weevils from the trees. Over 1100 were collected from a sheet spread under a tree dusted with pyrethrum, and from 200 to 450 were commonly brought down by derris and nicotine dusts. Most of the weevils dislodged by 4 per cent nicotine dust were only temporarily disabled. As shown in table 3 both pyrethrum and rotenone dusts gave a high percentage in mortality after 29 hours. It will be noted from a study of the data obtained in 1941 that most of the insects which were hit directly with the dusts died within 48 hours, but untreated beetles on dusted foliage lived about as long as the individuals in the check cages.

SUMMARY.—The apple flea weevil overwinters as an adult. Weevils of this generation are usually present in maximum numbers about the time cluster buds of the McIntosh variety are ready to separate. They feed on both the buds and leaves. The female oviposits usually in the midrib on the under side of the leaf, and the young larva mines between the two leaf surfaces pupating in a chamber at the margin. Adults of the new brood may be abundant from early May until late July after which time they go into hibernation.

DDT used at a concentration of 1 pound actual DDT in 100 gallons of spray was the most effective material tried in the tests for the control of the apple flea weevil. It gave considerable protection from beetle injury even when the concentration was reduced to 0.5 pound actual DDT. Fluorine compositions, chiefly cryolite, were nearly as effective as DDT. In preliminary trials both parathion and benzene hexachloride proved very effective against the insect. Pyrethrum and rotenone dusts were found to be toxic to the insects, but their practical use remains to be demonstrated.

The pest is most effectively controlled by sprays applied in early spring against the overwintering beetles. Summer treatments merely reduce the weevil population for the coming year. The experiments show that two treatments are more effective than one although in seasons of rapid blossom bud development one spray may prove sufficient. The appearance of the weevils is probably the most accurate guide for timing the first application, but for all practical purposes blossom bud development is more satisfactory. The first application is recommended at the pre-pink stage and the second, about a week later. Since the weevils feed mostly on the under sides of the leaves, special care should be exercised when spraying in order thoroughly to cover these areas with the insecticide.

LITERATURE CITED

Burks, B. D. 1943. The North American parasitic wasps of the genus *Tetrastichus*, Proc. U. S. Nat. Mus. **93** (3170) 585.

Houser, J. S. 1923. The apple flea weevil. Ohio Agr. Expt. Sta. Bul. **372**: 412–32.

Houser, J. S., and R. B. Neiswander. 1936. A new and effective control for the apple flea weevil. JOUR. ECON. ENT. **29**: 481–2.

Treatment of Mosquito Larvae and Adults with Radioactive Phosphorus[1,2,3]

W. W. YATES, C. M. GJULLIN, and ARTHUR W. LINDQUIST, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*, and JOSEPH S. BUTTS, *Oregon State College*

The use of radioactive isotopes in tagging insects for flight-range studies appears to have promise. Studies of the ratio of tagged to untagged recaptured mosquitoes would very likely give valuable clues as to the productivity of breeding areas and thereby aid in control activities. A more complete knowledge of the flight range of several species of mosquitoes is needed.

Hassett and Jenkins (1949) reported on rearing *Aëdes aegypti* (L.) mosquitoes in distilled water containing up to 10μc (microcuries) of radioactive phosphorus (P^{32}) per milliliter of water. Substantial but erratic counts of radioactivity were subsequently found in the adults. Bugher & Taylor (1949) reported on practical field studies with P^{32}-tagged mosquitoes.

Studies on the treatment of larvae and adults of floodwater *Aëdes* and *Culex tarsalis* (Coq.) mosquitoes with radioactive phosphoric acid (P^{32}) were begun in August 1949 at the Corvallis, Oreg., laboratory of the Bureau of Entomology and Plant Quarantine. These preliminary studies were concerned mainly with the problems of how to get the isotopes into the various stages of different species of mosquitoes, and the concentrations and dosages necessary to produce detectable amounts of radioactivity without injury to the insect. All tests for radioactivity were made by placing adult mosquitoes individually in metal counting dishes 1 inch in diameter and covering the dishes with scotch tape; counts were made with a thin-walled (1.85 mg./cm.^{2}) Geiger-Müller tube attached to a commercial-model 64 scaler. All counts given are above background.[4]

The first experiment consisted in administering an aqueous solution of radioactive phosphoric acid to mature rats intraperitoneally, and the next day allowing hungry mosquitoes, *Aëdes sticticus* (Meig.), to bite and suck blood from the rats. Each rat was given 0.375 millicurie of P^{32}. The mosquitoes appeared to be normal and showed no ill effects from the rat blood. Radioactivity tests on six of these mosquitoes gave 740, 893, 897, 881, 776, and 544 counts per minute (cpm). Untreated mosquitoes gave counts equal to but no more than background. Three of the treated mosquitoes were grossly dissected, and the radioactivity of each part was determined (Table 1). The total count for the component parts was close to that obtained with the intact mosquito. Approximately 72 per cent of the radioactivity was found in the abdomen and 4 per cent in the legs.

Table 1.—Radioactivity of three *Aedes sticticus* mosquitoes given a blood meal on mature rats that had received 0.375 millicurie of P^{32} 24 hours earlier.

	No. 1		No. 2		No. 3	
PART EXAMINED	Cpm	Per cent of total	Cpm	Per cent of total	Cpm	Per cent of total
Before dissection	897	—	881	—	776	—
After dissection:						
Head	28	3.1	28	3.1	24	3.0
Thorax	188	21.1	172	19.3	177	21.8
Abdomen	631	71.0	649	73.0	582	71.8
Legs	36	4.1	40	4.5	28	3.4
Wings	6	0.7	1	0.1	0	0
Total	889	100	890	100	811	100

A second experiment was made to determine whether mosquito larvae would develop in a medium containing P^{32}. Two droppings from the rats which had been used in the previous experiment were placed in a vessel containing 50 ml. of water, and 25 second- and third-instar larvae of *Culex tarsalis* (Coq.) mosquitoes were introduced therein. The larvae developed into adults. The amount of P^{32} in the rat droppings was very small. The radioactivity for six of the test insects (five females and one male) before and after dissection is given in table 2. Approximately 15 per cent of the total radio-

[1] This research was supported in part by the Atomic Energy Commission under a contract administered by the Office of Naval Research to Oregon State College.

[2] Published as Technical Paper No. 644 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution of the Department of Agricultural Chemistry.

[3] Presented at the Pacific Slope Branch Meeting of the American Association of Economic Entomologists at Santa Cruz, Calif., June 14–16, 1950.

[4] All sensitive radiation-measuring instruments show a small reading even when no radioactive sources are in the vicinity. This residual reading, or background, is due to cosmic rays, to radioactive materials in the vicinity, and to a slight radioactive contamination of the materials of which the instrument is made.

Table 2.—Radioactivity of six adult *Culex tarsalis* mosquitoes reared from a mixture of second- and third-stage larvae in a medium containing an unknown amount of P^{32}.

	No. 1		No. 2		No. 3		No. 4[1]		No. 5		No. 6	
PART EXAMINED	Cpm	Per Cent of Total	Cpm	Per Cent of Total	Cpm	Per Cent of Total	Cpm	Per Cent of Total	Cpm	Per Cent of Total	Cpm	Per Cent of Total
Before dissection	164	—	380	—	266	—	297	—	382	—	349	—
After dissection:												
Head	21	13.6	168	46.0	7	2.7	19	6.9	8	3.0	12	4.0
Thorax	55	35.5			110	34.9	115	42.0	79	30.0	69	22.7
Abdomen	56	36.1	161	44.1	159	50.5	114	41.6	122	46.4	150	49.5
Legs	23	14.8	36	9.9	39	12.4	26	9.5	54	20.6	72	23.8
Wings	0	0	0	0	0	0	0	0	0	0	0	0
Total	155	100	365	100	315	100	274	100	263	100	303	100

[1] Male; all others were females.

activity was in the legs and 45 per cent in the abdomens.

A third experiment was made to determine whether the P^{32} could be given to mosquito adults in a manner different from that previously described. Twenty-five *Aëdes sticticus* adults were starved for 2 days and then permitted to feed on a solution containing an unknown concentration of the radioactive phosphorus and approximately 10 per cent of sugar. The mosquitoes fed avidly, and at intervals of 3 to 4 days thereafter the radioactivity of the intact insect as well as that of the grossly dissected parts was recorded. The results obtained with five females are given in table 3. The last mosquito was dissected 13 days after feeding, at which time a detectable amount of radioactivity was demonstrated. Approximately 9 per cent of the total radioactivity was in the legs and 41 per cent in the abdomens. Not included in the table are results obtained with one intact male and one intact female, which gave counts of 549 and 688.

In December another sample of radioactive phosphoric acid became available, and it was planned to determine the minimum dosages required for mosquito larvae to give measurable radioactivity in the adults after they emerged several days later. The starting date for calculating decay of the P^{32} was December 15, although the sample had been removed from the pile 3 days previously. For the tests started after December 15 a correction for decay of the P^{32} was made in calculating dosages. No correction for decay was made between the time a test was started and the subsequent emergence and measurement of radioactivity of adult mosquitoes.

Second and third instars of a 90:10 mixture of *Aëdes sticticus* and *A. vexans* (Meig.) reared from eggs under standard

Table 3.—Radioactivity of five female *Aëdes sticticus* mosquitoes fed a sugar solution containing P^{32}

	No. 1		No. 2		No. 3		No. 4		No. 5	
PART EXAMINED	Cpm	Per Cent of Total	Cpm	Per Cent of Total	Cpm	Per Cent of Total	Cpm	Per Cent of Total	Cpm	Per Cent of Total
Before dissection	793	—	577	—	1148	—	1192	—	792	—
After dissection:										
Head	148	18.9	32	5.9	38	3.9	34	2.5	44	5.0
Thorax	245	31.3	207	37.9	469	49.1	482	35.5	382	42.9
Abdomen	347	44.3	262	48.0	321	33.6	560	41.4	351	39.4
Legs	38	4.9	45	8.2	128	13.4	125	9.2	100	11.2
Wings	5	0.6	0	0	0	0	155	11.4	13	1.5
Total	783	100	546	100	956	100	1356	100	890	100

Table 4.—Radioactivity of *Aëdes sticticus* and *A. vexans* adults reared from second- and third-instar larvae in water containing P^{32}.

Date Test Was Started	P^{32} in Rearing Medium (μc Per Milliliter)	Days Before Counts Were Made	Number of Mosquitoes Tested		Radioactivity (cpm)			
					Females		Males	
			Females	Males	Range	Average	Range	Average
1949					Second-instar larvae			
Dec. 15	0.05	7	5	4	30,832–48,096	41,147	35,656–45,232	39,072
	.01	7	5	5	7,856–10,136	8,888	5,440– 7,960	6,641
1950								
Jan. 12	.01	7	4	4	11,643–19,070	14,911	7,908–15,616	12,073
		8[1]	2	1	6,281– 6,725	6,503	—	—
	.001	7	3	3	1,514– 1,871	1,612	1,061– 1,227	1,158
		8	2	2	782– 1,027	905	452– 365	509
	.0001	7	4	3	369– 706	522	341– 496	399
		8[1]	2	1	296– 399	318	174	174
					Third-instar larvae			
Jan. 12	.01	7	3	2	5,159–10,605	7,977	6,395– 7,412	6,903
	.001	7	3	3	1,134– 1,462	1,289	818– 1,401	1,018
		8[1]	1	—	591	591	—	—

[1] Late-emerging adults.

conditions were used. Twenty-five healthy larvae of the same instar were placed in each test vessel containing 200 ml. of tap water plus a sufficient amount of radioactive phosphoric acid to obtain the desired concentration (from 0.05 to 0.0001 μc of P^{32} per milliliter). The larvae were supplied with food and kept at a constant temperature of 80° F. Upon emerging the adults were trapped in a screen-wire cage.

The results are given in table 4. In the tests started on January 12 higher counts were obtained than in those started on December 15, as indicated by the one dosage (0.01 μc) that was repeated. The tests did not show a consistent relationship between the concentrations and the counts obtained. For example, the counts for the 0.01-μc concentration should have been 100 times that for the 0.001-μc dosage, or 52,200, but the average count was only 14,911.

Since the lowest concentration to which larvae were exposed (0.0001 μc per milliliter) gave 522 cpm on the females and 399 cpm on the males, it appears that this or even lower concentrations might be used in practical field tests where it is desired to tag mosquitoes in their natural breeding areas. With suitable measuring equipment it is likely that one-tenth this concentration would prove adequate. A concentration of 0.0001 μc per milliliter equals only 1 μc to 10 liters of water. This concentration would be practical to treat pools of water producing thousands of mosquitoes. Moreover, the demonstrations that adult mosquitoes can be readily tagged by feeding them sugar solutions containing small amounts of P^{32} makes it possible readily and economically to treat the adults directly for flight and various other studies.

SUMMARY.—Studies were made to determine how to introduce radioactive phosphoric acid (P^{32}) into both larvae and adult mosquitoes in amounts that would be detectable with radioactive measuring devices. *Aëdes sticticus* (Meig.) and *A. vexans* (Meig.) mosquitoes gave 544 to 897 cpm above background after they had been allowed to feed on the blood of rats that had received 0.375 millicurie of P^{32} in aqueous solution intraperitoneally 24 hours earlier. In three dissected specimens an average of 72 per cent of the radioactivity was found in the abdomen and 4 per cent in the legs.

Second- and third-instar larvae of *Culex tarsalis* (Coq.) reared in water having an unknown concentration of P^{32} had radioactivity ranging from 164 to 417 cpm. Fifteen per cent of this radioactivity was present in the legs and 45 per cent in the abdomen.

Aëdes sticticus females fed on water having an unknown concentration of P^{32} gave readings of 577 to 1,192 cpm 1 to 13

days later. The legs had approximately 9 per cent and the abdomens 41 per cent of the total radioactivity.

Aëdes sticticus and *A. vexans* adults reared from the second-stage larvae in water containing 0.05 μc of P^{32} per milliliter gave average readings of 41,147 cpm for females and 39,072 cpm for males. In later tests dosages of 0.01, 0.001, and 0.0001 μc per milliliter gave 14,911, 1,612, and 522 cpm, respectively, for the females.

It is suggested that a concentration of approximately 0.0001 μc of radioactive phosphoric acid per milliliter may be a practical dosage for the treatment of larvae in flight studies of adults. Since adults may be readily tagged by feeding them sugar solutions containing small amounts of P^{32}, the use of this method may be desirable in many studies.

LITERATURE CITED

Bugher, J. C., and Marjorie Taylor. 1949. Radiophosphorus and radiostrontium in mosquitoes. Science 110(2849): 146–7.

Hassett, C. C., and D. W. Jenkins. 1949. Production of radioactive mosquitoes. Science 110(2848): 109–10.

Biological Control of Mealybugs Infesting Commercial Greenhouse Gardenias

RICHARD L. DOUTT, *Division of Biological Control, University of California*

The physical conditions in commercial greenhouses approach an optimum environment for the existence and increase of many pests, particularly such insects as mealybugs and soft scales. These same physical environmental factors plus the abundance of hosts in a limited area offer nearly ideal conditions for the efficient utilization of natural enemies in the biological control of these pests.

In view of the potentialities of the biological control method under these circumstances, surprisingly little effort has been made to test the effectiveness of entomophagous insects on greenhouse pests. In advocating the use of *Encarsia formosa* Gahan for the control of the greenhouse white fly, *Trialeurodes vaporariorum* (Westwood), Speyer (1927) was apparently the first to study the subject scientifically, and satisfactory control of this pest has been indicated. Pritchard (1949) reported that the ladybird beetle, *Cryptolaemus montrouzieri* Mulsant, and the Sicilian mealybug parasite, *Leptomastidea abnormis* (Girault), have been released by growers to a limited extent in gardenia ranges for the control of the citrus mealybug. Pritchard stated that the results have been variable, but in general the mealybug populations have been considerably decreased but not eliminated. He reasons, quite logically, that the use of such predators and parasites is impractical when they are killed by insecticides which may be used for the control of other pests.

An opportunity arose during 1950 to make a study of the effectiveness of entomophagous insects in controlling the citrus mealybug, *Pseudococcus citri* (Risso), on greenhouse gardenias, and to determine the compatibility of this method with normal greenhouse cultural practices. A grower of gardenias offered the use of a large greenhouse for this work. This house contained approximately 3000 plants, all of which were heavily infested with citrus mealybug. The grower agreed to withhold insecticidal treatment of the mealybugs although the practice of syringing the plants with water was continued. The understanding with the grower, however, was that he should take whatever measures he felt necessary to control other pests which might threaten the plants, such as mites, aphis, scales, or leafrollers. In order to evaluate the effectiveness of biological control in this greenhouse (designated as A), a comparison was made with two other greenhouses containing gardenia plants of approximately the same age and degree of infestation. In one of these check houses (designated as C) the grower periodically applied tetraethyldithio-pyrophosphate in aerosol form, and in the other hourse (B) no measures were taken to suppress the mealybugs.

The percentage of budding terminal shoots which were infested with mealybugs throughout each house was used as the criterion for determining the effectiveness of the control. Preliminary examinations of 2800 such terminals in each greenhouse indicated that the infestation was not spotted, but rather evenly distributed throughout the house. This was particularly true since the presence of a single mealybug in any stage of development classified a terminal shoot as infested. At the beginning of the study it was common to find terminals infested with several hundred mealybugs. The population density of the mealybugs was undoubtedly not the same on every plant, nevertheless each plant was infested. The criterion selected for evaluating this work therefore demands an extraordinarily clean house before the data become impressive.

At the outset each house was found to have present both *Cryptolaemus montrouzieri* and *Leptomastidea abnormis*. These insects had apparently been introduced a number of years previously, and had maintained themselves under greenhouse conditions. However, the degree of mealybug infestation made it obvious that they did not consistently suppress the pest to a low level. The best explanation for the inability of *Cryptolaemus* continually to hold the mealybugs in check is that for long periods of time the greenhouse temperatures fall below the minimum activity threshold for *Cryptolaemus*, which threshold is 70° F. according to Smith & Armitage (1931). Hygrothermograph records during March and April showed that the temperature in the greenhouse reached 70° F. for a brief period only during the middle of the day. Such a condition undoubtedly also occurs during the colder months prior to March. Since the citrus mealybug can increase at a lower temperature than the *Cryptolaemus*, it soon grows away from this natural enemy. The activity of *Leptomastidea* at these low temperatures has not been determined.

This investigation on the biological control of citrus mealybugs on gardenias was begun on April 1. Several different species of natural enemies of the citrus mealybug were available at that time in the insectary of the Division of Biological Control of the University of California's Agricultural Experiment Station. These were liberated periodically in the biological control greenhouse A in small lots until June 15. Included in the releases were the predatory species: *Chrysopa californica* Coquillett, *Scymnus binaevatus* Mulsant, *Scymnus quadrivittatus* Mulsant, *Exochomus flavipes* (Thunberg), *Chilocorus angolensis* Crotch, and *Hyperaspis lateralis* Mulsant. The species of parasites introduced into the greenhouse were *Anagyrus kivuensis* Compere and *Tropidophryne melvillei* Compere.

Of these eight species of predators and parasites it was soon evident that three were established and destroying mealybugs. These were *Chrysopa californica*. *Exochomus flavipes*, and *Anagyrus kivuensis*. These continued to maintain themselves while the other five species soon disappeared. Although heavy parasitism of mealybugs and great activity of the predators was soon evident and a tremen-

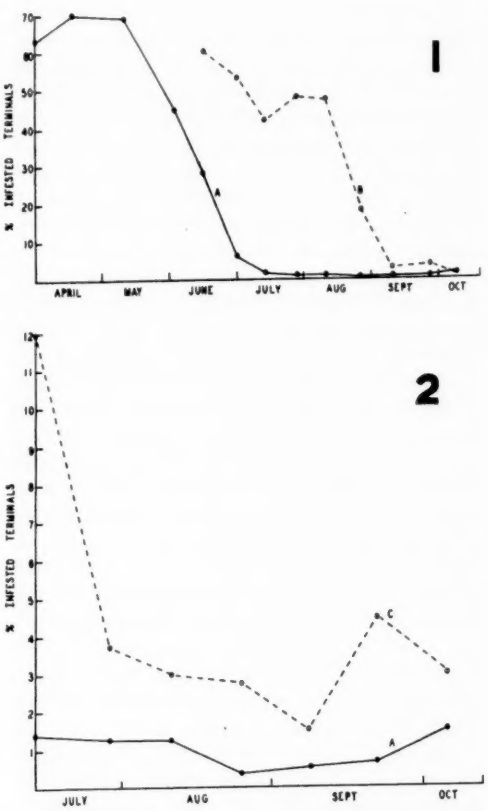


FIG. 1. (1) Comparison of mealybug infested terminals in greenhouses "A" and "B."
(2) Comparison of mealybug infested terminals in greenhouses "A" and "C."

dous reduction of the mealybug population occurred, the complete extermination of mealybugs from the terminals took more time, and not until about the last of June did the clean terminals appear commonly in the samples (Fig. 1). From July until October the mealybug infestation in the biological control house "A" remained at a very low level, averaging less than 1 per cent of the terminals infested (Figs. 1 and 2).

With the advent of warmer weather the *Cryptolaemus* and *Leptomastidea* in greenhouse "B" began to be effective in reducing the mealybug population (Fig. 1). In August it was discovered that *Exochomus* had been accidentally introduced into greenhouse "B," probably by being transported on the clothing of greenhouse workers and flower pickers who make frequent trips through all the greenhouses each day and whose normal routine takes them directly from greenhouse "A" to greenhouse "B." Thus the usefulness of greenhouse "B" as a check was nullified and the effective work of *Exochomus* together with that of the other species resulted in a quick reduction of mealybugs. By October the infestation was about equal in houses "A" and "B" (Fig. 1, 1).

Greenhouse "C" received the first application of tetraethyl-dithio-pyrophosphate on July 12, and a count of mealybugs made a day later showed that the population had fallen markedly so that only 12 per cent of the terminals were infested. Applications of this insecticide were made by the grower at intervals from July to October for the control of mealybugs and mites, and although the material is very effective against mealybugs, the infestation in greenhouse "C" never was held as low as in the biological control greenhouse "A" (Fig. 1, 2).

A light infestation of hemispherical scale, *Saissetia hemisphaerica* (Targioni), was present in all three greenhouses at the beginning of this investigation. The scale was found to be attacked by *Metaphycus helvolus* (Compere) and *Encyrtus infelix* (Embleton). After the applications of tetraethyl-dithio-pyrophosphate in greenhouse "C" the infestation by this scale increased enormously and on September 8 a comparative count showed 83 per cent of the terminals in this house infested as contrasted with only 1.5 per cent of the terminals infested in the biological control house.

For control of mites the grower periodically applied tetraethyl-pyrophosphate to the steam pipes in greenhouses "A" and "B." The degree of control was noticeably less than that attained in greenhouse "C" where tetraethyl-dithio-pyrophosphate had been employed. The tetraethyl-pyrophosphate, however, apparently did not affect the beneficial insects in the greenhouses, and laboratory tests have confirmed this observation.

The practical use of natural enemies for the biological control of mealybugs in greenhouses appears to be dependent primarily upon the use of an effective acaricide which must at the same time be innocuous to entomophagous insects. Such acaricides do exist but apparently not in aerosol form, and most cut-flower greenhouse operators today prefer to employ aerosols rather than practice the more laborious spraying of plants. It is understandable, too, that growers should seek a "package deal" insecticide which in one application will control several pests. The chemical used in greenhouse "C" was effective against mites and mealybugs but permitted a startling increase of soft scale insects which in turn required applications of cyanide.

This investigation serves as a demonstration, however, that biological control can be a very effective method of combating certain greenhouse pests such as mealybugs and soft scales. The selection of entomophagous insects for this test was made only from those readily at hand, and these species are, perhaps, not as efficient as others which could be obtained or are now available, such as *Pauridia peregrina* Timberlake, *Leptomastix dactylopii* Howard, or *Allotropa* sp. The possibilities of making biological control in greenhouses even more effective than is indicated here are therefore very real.

This demonstration of biological control is submitted to show the extreme effectiveness of the method, its economy, and its absolute safety to plants and human health. However, so long as the margin of profit permits regular periodic treatment of greenhouses, so long as insecticide-resistant races of insects do not appear, and so long as the condition of the plants and the health of the humans work-

ing in the greenhouses are not impaired by the application of toxic chemicals, it is probable that biological control will not be used throughout the greenhouse industry.

SUMMARY.—A very heavy infestation of *Pseudococcus citri* (Risso) on commercial greenhouse gardenias was reduced to a low level and maintained under control by introducing several species of parasites and predators. The most effective species were *Exochomus flavipes* (Thunberg), *Anagyrus kivuensis* Compere, and *Chrysopa californica* Coquillett.

The method was found to be practical if used in conjunction with an acaricide which is innocuous to beneficial insects. Under these conditions, biological control of *Saissetia hemisphærica* (Targioni) also occurred as a result of the parasitic activities of *Metaphycus helvolus* (Compere) and *Encyrtus infelix* (Embleton).

Because of the favorable environment in greenhouses, biological control has many possibilities which have not been explored. A great number of entomophagous species exist which may be even more efficient than those tested during the course of this investigation.

LITERATURE CITED

Pritchard, A. E. 1949. California greenhouse pests and their control. Calif. Agr. Expt. Sta. Bul. 713: 1–71.

Smith, H. S., and H. M. Armitage. 1931. The biological control of mealybugs attacking citrus. Calif. Expt. Sta. Bul. 509: 1–74.

Speyer, E. R. 1927. An important parasite of the greenhouse white-fly (*Trialeurodes vaporariorum* Westwood). Bul. Ent. Res. 17: 301–8.

Sugars and Protein in the Corn Plant as Related to Nutrition of the European Corn Borer

G. T. BOTTGER, *Bureau of Entomology and Plant Quarantine, Agr. Res. Adm., U.S.D.A.*[1]

To establish more definitely the relation of sugars and protein to nutrition of the corn borer, *Pyrausta nubilalis* Hbn., larvae were reared on different parts of the corn plant that had been treated to vary the carbohydrate and protein content (Bottger 1940, 1942). To compare the nutritive values of the various food materials, the respective sugar and protein contents of the media were determined, and the larvae fed on each material were weighed at 4-day intervals, beginning when they were 10 days old and continuing through the thirtieth day of their development. All the corn was grown and all the larvae were reared at the Toledo, Ohio, laboratory of the Bureau of Entomology and Plant Quarantine.[1]

Immediately after each lot of leaves and internodes was harvested, it was cut into convenient lengths for handling and feeding and was preserved by quick freezing. Corn kernels were cut from the cob before they were frozen. A well-insulated zinc-lined wooden box 24 by 36 by 24 inches, fitted with a tight hinged cover and equipped with two zinc trays 4 inches deep (one to hold the material to be frozen, and supported 2.5 inches above the bottom floor by metal legs, and the other to hold 25 to 50 pounds of dry ice placed on top of the first), provided an efficient quick-freezing chamber. A temperature of −30° F. was attained in the center of the material that was to be frozen within 2 hours. The purpose of quick-freezing the plant tissue was twofold—first, to preserve a homogeneous sample of material to supply a group of test larvae exactly the same kind of food during the entire feeding period of each experiment; second, to preserve in a like manner, a composite sample of the same tissue for the chemical analyses, which, of necessity, were made later. Quick-freezing provided a convenient, economical, and entirely satisfactory method of preserving tissue for both purposes.

Golden Cross Bantam sweet corn was planted on three successive dates in May,

[1] The chemical analyses were made through the cooperative efforts of W. H. Stoneburner, J. D. Sayre, and V. H. Morris of the Bureau of Plant Industry, Soils, and Agricultural Engineering, working at the Ohio Agricultural Experiment Station, Wooster, Ohio.

Table 1.—**Average chemical analyses of three types of nutritive media from Golden Cross Bantam corn, average weights per larva at six successive ages, and percentages of larvae surviving at the end of 30 days.**

Nutritive Media	Average Chemical Analyses of Plant Tissue in Per Cent of Green Weight				Per Cent Survival of Larvae After Feeding 30 Days	Average Weight per Larva in Milligrams After Feeding—					
	Reducing Sugar	Invert Sugar	Total Protein N×6.25	Total Moisture		10 Days	14 Days	18 Days	22 Days	26 Days	30 Days
Leaves	1.1	0.4	2.8	78.8	27.5	3.1	6.1	8.0	10.2	14.3	15.5
Kernels	2.7	.9	3.0	78.7	25.5	7.2	17.9	32.2	47.1	59.8	72.9
Internodes	5.4	2.6	.8	83.2	15.2	1.9	3.7	6.8	12.7	18.1	24.8

to supply green plant tissue in various stages of maturity for the nutrition tests. In one group of plants the proportion of sugars in stalks and kernels was reduced by clipping off the leaves about 3 weeks before harvest. On another group the amount of sugars within the stalks was increased by bagging the ears. Still other plants were harvested at different stages of maturity, to obtain leaves, kernels, and stalks having different proportions of sugars and protein (Sayre, *et al.* 1931).

Internodes from two other strains of sweet corn, namely, Michigan 1828 (resistant) and Connecticut C2 (susceptible) and two strains of dent corn, R4 X Hy (resistant) and A X TR (susceptible), were included for comparison, because extensive field tests had indicated that they represented strains of sweet and dent corn comparatively resistant or susceptible to borer attack.

Immediately after freezing, 700 grams of each sample were placed in a thickly paraffined 1-gallon ice-cream container and were transferred to cold storage (about 20° F.) without being allowed to thaw, for subsequent chemical analysis. Another 700-gram sample was subjected to incubator conditions for 24 hours to represent food at the time it was replaced in the cages by fresh material, refrozen, and placed in cold storage to await transportation to Wooster, where all samples were analyzed. Two 300-gram samples of each material were preserved, after 24 hours in the incubator, by boiling in 95 per cent alcohol for 15 minutes, to serve as checks against the frozen tissue and to determine whether or not the second freezing caused any appreciable chemical changes in the tissue. The remainder of each lot of tissue was packed into 30 small tin containers, each of which held enough food to supply the test larvae for 24 hours. Only one day's supply of food was removed from cold storage each day, the remainder being left undisturbed, to avoid repeated exposure of the entire supply to warm air.

Two hundred newly hatched corn borer larvae were fed on each material, 25 being reared in each of 8 separate cages. The larvae were transferred to fresh food and clean rearing cages daily. After they had been fed for 10 days, 20 of the surviving larvae were isolated and records were kept, including weights at six successive ages, until they were 30 days old.

Rearing cages used in these tests consisted of glass crystallizing dishes, 45 mm. wide by 35 mm. deep, each covered with a piece of muslin stretched tightly across the top and securely held in place by means of a rubber band. During the later instars, when the larvae have a tendency to chew through the cloth, the muslin was replaced with an 80-mesh

Table 2.—**Chemical analyses of leaf tissue of Golden Gross corn, per cent survival and weights of larvae at six successive stages of maturity.**

Sample No.	Maturity of Plants from Which Media Were Taken	Chemical Analyses of Plant Tissue, in Per Cent of Green Weight				Per Cent Survival of Larvae After Feeding 30 Days	Average Weight per Larva in Milligrams After Feeding:					
		Reducing Sugar	Invert Sugar	Total Protein	Total Moisture		10 Days	14 Days	18 Days	22 Days	26 Days	30 Days
1	5 days before tasseling	1.1	0.4	2.6	79.8	24.5	2.9	5.2	6.5	7.9	10.8	12.6
2	Day tassels appeared	1.1	.2	2.4	80.0	25.0	2.9	8.3	9.1	10.3	15.0	15.4
3	5 days after tasseling	1.1	.5	3.4	76.6	33.0	3.4	4.7	8.5	12.4	17.0	18.4
	Average	1.1	0.4	2.8	78.8	27.5	3.1	6.1	8.0	10.2	14.3	15.5

Table 3.—Chemical analyses of corn internodes and resultant survivals and weights of test larvae at six successive ages.

Variety of Nutritive Media Tested (Internodes)	Maturity of Plants from Which Media Were Taken	Chemical Analysis of Plant Tissue, in Per Cent of Green Weight				Per Cent Survival of Larvae After Feeding 30 Days	Average Weight per Larva in Milligrams After Feeding—					
		Reducing Sugar	Invert Sugar	Total Protein N×6.25	Total Moisture		10 Days	14 Days	18 Days	22 Days	26 Days	30 Days
1. Golden Cross Bantam	Mid-tasseling	3.4	0.3	0.9	77.2	27.4	2.5	5.6	11.5	18.7	23.5	29.9
2. Golden Cross Bantam	18 days after mid-tasseling	5.1	1.2	.8	87.2	28.8	3.1	5.7	11.6	17.4	19.6	25.3
3. Golden Cross	23 days after mid-tasseling (leaves clipped)	5.8	3.6	.6	84.5	7.1	1.9	2.6	3.3	3.9	11.6	17.8
4. Golden Cross Bantam	25 days after mid-tasseling (ears bagged)	7.1	7.5	1.1	80.4	3.9	1.6	3.0	5.8	10.5	12.2	12.8
5. Mich. 1828	4 days after mid-silking	5.2	1.0	1.0	86.2	11.1	1.6	4.4	8.7	17.3	24.2	38.6
6. Conn. C2	Mid-silking	5.2	1.8	.9	86.4	16.4	1.7	3.0	5.8	12.4	27.2	33.0
7. R4×Hy	Mid-silking	6.9	2.9	.8	80.9	10.7	.9	2.6	2.9	6.7	12.0	18.2
8. A×TR	Mid-silking	5.4	2.9	.6	82.4	16.4	1.9	2.4	4.4	8.8	14.2	22.4
Average		5.5	2.6	0.8	83.2	15.2	1.9	3.7	6.8	12.0	18.1	24.8

copper screen disc cut to the same circumference as the dish and held in place by a rubber band.

Kinds of plant tissue tested, chemical composition, per cent survival at the end of 30 days, and average weights of larvae at six successive ages, representing average results from three leaf, eight internode, and six kernel samples, are presented in table 1.

A preliminary examination of the data reveals appreciable differences in the average chemical composition of leaves, internodes, and kernels, considered as separate groups. Similarly test larvae reared on the different media showed wide differences in rates of growth, as expressed in weights. It is believed that the biological reactions of the test larvae were materially influenced by the differences in the physical structure of the various types of plant tissue on which they were reared. Comparisons of the effects of variations in sugar and protein should therefore be confined within each particular type. However, a comparison of averages for each type probably serves best to illustrate the heterogeneity of the three types and also indicates a relation between the different proportions of sugars and protein in the nutritive media and the biological reactions of the larvae.

After noting the relatively high percentage of protein present in the leaf tissue, it seems reasonable to assume that a sugar deficiency may have prevented the larvae reared thereon from developing as fast and attaining as much weight as those reared on kernels. Since survival of larvae was fully as high on leaves as on kernels, it does not seem likely that the different structural characteristics of these tissues were materially responsible for the differences in the growth of these two groups of larvae.

Lack of protein may have been chiefly

Table 4.—Chemical analyses of sweet corn kernels and resultant survivals and weights of test larvae at six successive ages.

Sample No.	Maturity of Plants from Which Kernels Were Taken (Days After Mid-Silking)	Chemical Analyses of Plant Tissue in Per Cent of Green Weight				Per Cent Survival of Larvae After Feeding 30 Days	Average Weight per Larva in Milligrams After Feeding:					
		Reducing Sugar	Invert Sugar	Total Protein	Total Moisture		10 Days	14 Days	18 Days	22 Days	26 Days	30 Days
1	10	4.2	0.3	2.3	88.2	20.6	10.7	26.6	41.1	63.9	77.8	88.8
2	5	3.8	.4	3.9	77.4	28.8	9.6	23.0	40.7	62.4	69.8	77.9
3	25	2.5	1.4	3.6	67.8	27.9	3.9	10.6	17.8	24.8	38.3	61.4
4	15	2.3	.6	3.2	78.8	35.7	7.2	20.0	44.5	53.4	78.8	88.8
5	20 (leaves clipped)	2.2	1.3	2.2	81.0	18.7	3.8	9.2	20.0	31.3	36.8	56.2
6	15 (plus heat treatment)	1.5	1.3	3.0	78.7	21.2	7.7	17.7	28.8	46.6	57.1	64.3
Average		2.7	0.9	3.0	78.7	25.5	7.2	17.9	32.2	47.1	59.8	72.9

responsible for the slow growth and low survival of larvae on internodes. However, the extremely light weights of these larvae during the first half or two-thirds of the 30-day test period, and the sharp gains in weight of the few survivors during the last third of their growth period, indicate that some mechanical factor may have prevented the young larvae from taking advantage of the nutritive substances present. Despite the fact that the internodes were relatively low in protein, the few larvae surviving on them to the end of the 30-day period averaged more than one-third heavier than those reared on leaves at the end of the same period. The higher sugar content of the internodes in comparison with that of the leaves is the only measured factor that can be associated with the higher weights of the larvae reared on internodes. The great superiority of the kernels to either of the other types of media in meeting the borer's nutritive requirements, as indicated by the much higher average weight of larvae reared on kernels, apparently is due to their comparatively high content of both protein and sugars. Although they contained much less sugar than the internodes, they were much richer in this food element than were the leaves.

The chemical analyses of leaf tissue harvested from sweet corn plants at three different stages of maturity and the survivals and weights of larvae reared thereon are presented in table 2.

The reducing sugar present in each of the three leaf samples is uniformly low and all the weights of larvae at the end of 30 days of feeding are also comparatively low, though not so uniformly low. Sample No. 3 had slightly higher percentages of sugar and protein accompanied by slightly greater weights and survivals of larvae, but these higher percentages may not be significant. Even if they were significant, the results of some of the other tests contradict the likelihood that they are primarily due to such small differences in amount of protein at such a comparatively high protein level.

The chemical analyses of corn internodes representing four different samples of Golden Cross Bantam, the resistant and susceptible sweet corn strains, Mich. 1828 and Conn. C2, and the resistant and susceptible dent corn strains, R4 X Hy and A X TR, are presented in table 3.

About the only consistent results apparent in the data on internodes is the increase in total sugar content with advance in maturity of samples 1 to 4, inclusive. The alteration of plants from which samples 3 and 4 were taken appears to have affected the carbohydrate constituents to some extent, and also to have affected further the nutritive qualities of the plant tissue. These effects are reflected in the low weights and survivals of test larvae reared on samples 3 and 4. On the basis of the response of test larvae to other media of known sugar and protein content, the writer assumed that all the internode samples contained percentages of reducing sugars far in excess of the borer's requirements. This fact may explain the absence of any association between reducing sugars and the biological reaction of larvae reared on these internodes. There have also been indications in previously taken data that the borer does not respond favorably to invert sugars in its diet, and in some tests these sugars apparently had a detrimental effect without reducing sugar supplements. The excessive amount of this constitutent may be associated with the unfavorable response of test larvae in samples 3 and 4.

Survival of larvae tested on internodes from the two resistant strains averaged about one-third less than on either of the susceptible strains. Final weights of larvae on A X TR (susceptible) average 18.7 per cent higher than those reared on R4 X Hy (resistant) internodes, but the final weights of larvae on Mich. 1828, a resistant sweet corn strain, averaged 14.5 per cent more than the final weight of larvae on Conn. C2, a strain reported to be susceptible. The differences between survivals and weights of larvae reared on resistant and susceptible strains of either dent or sweet corn cannot be attributed to differences in the measured chemical constituents of these corn strains. Since structural composition of plant tissue doubtless varies with plant maturity, and also from strain to strain, its effect seems to be suggested here. The greater final weights of larvae from each of the sweet corn strains, as compared with those resulting from either of the dent variations, may possibly be due to the higher pecentage of proteins present in the sweet corn.

The chemical analyses of Bantam sweet

corn kernels harvested from plants at five different stages of maturity and the survivals and weights of larvae reared thereon appear in table 4. Sample No. 6 in table 4 was harvested at the same time and from the same plants as sample 4, but was heated 30 minutes at 55° C.

A comparison of weights of larvae reared on different samples within the kernel group indicates a more obvious and consistent relation between the amount of reducing sugar in the diet and resultant weights than between additional quantities of protein matter and increases in weights. The influence of plant alteration on the nutritive qualities of sample 5, in addition to that revealed in the chemical analyses, is here again reflected in relatively low survival and weights of larvae tested on this medium. Also, there again appears to be some relation between increases in the percentage of invert sugar in the diet and decreases in weights of larvae. While the survivals of larvae are not entirely consistent with the results expressed in weights, low survivals do correspond with the lower weights of larave in two of the three samples where weights were relatively low. Relatively high survivals of larvae also occurred along with relatively high weights of larvae in two of three samples where the weights were highest. In addition to the ample and effective supply of reducing sugars and protein present in green sweet corn kernels, which also provide an excellent nutritive medium for all stages of larvae, it is probable that growth-promoting vitamins and fats, which are concentrated in the kernels, contribute appreciably to their effectiveness in satisfying the nutritive requirements of the corn borer.

SUMMARY.—An experiment was designed to determine the relation of sugar and protein contents of different parts of the growing corn plant to the nutrition of the European corn borer, *Pyrausta nubilalis* Hbn. as measured by survival and weight of larvae reared thereon in the Toledo, Ohio, Laboratory of the Bureau of Entomology and Plant Quarantine.

Immediately after harvesting, test samples of corn leaves, internodes, and kernels were quick-frozen. The kernels were cut from the cob before freezing. Larvae were reared in the laboratory on different parts of the corn plant so harvested or otherwise treated so as to vary their carbohydrate and protein content. To determine their growth rates the larvae were weighed at 4-day intervals, beginning when they were 10 days old and continuing through the thirtieth day of their development.

Wide differences were apparent in the chemical composition of leaves, internodes, and kernels and in the average survivals and growth rates of test larvae reared on these different parts of the plants.

The leaves contained only one-fifth of the average amount of reducing sugar (1.08 per cent of their green weight) as was present in the internodes and little more than one-third the amount contained in the kernels. However, the leaves were relatively high in protein (2.80 per cent of their green weight). High survivals but low weights of larvae resulted when they were restricted to leaf tissue for food.

Corn internodes were high in sugar content but relatively low in protein. Feeding the larvae exclusively on internode tissue resulted in low survival with relatively high weights.

Weights of larvae reared on sweet corn kernels varied more consistently with differences in reducing sugar content than with differences in protein content. High weights of larvae reared on sweet corn kernels also tended to be associated with high survival.

There was some indication that the borers did not respond favorably to increases in the percentage of invert sugars in their diet, and that these sugars had a detrimental effect on them where there was a deficiency of reducing sugars.

LITERATURE CITED

Bottger, G. T. 1940. Preliminary studies of the nutritive requirements of the European corn borer. Jour. Agr. Research **60**(4): 249–57.

Bottger, G. T. 1942. Development of synthetic food media for use in nutrition studies of the European corn borer. Jour. Agr. Research **65**(10): 493–500.

Sayre, J. D., V. H. Morris, and F. D. Richey. 1931. The effect of preventing fruiting and of reducing the leaf area on the accumulation of sugars in the corn stem. Jour. Am. Soc. Agron. **23**(9): 751–3.

The Effect of Alfalfa Dehydration Upon Residues of Aldrin, Chlordane, Parathion, and Toxaphene[1]

ROY E. STANSBURY[2] and PAUL A. DAHM,[3] *Kansas Agricultural Experiment Station, Manhattan*

Alfalfa is rated as the most important forage crop in the United States. In recent years there has been an increasing use of the new synthetic organic insecticides for the control of insects attacking alfalfa. In this paper, the effect of commercial alfalfa dehydration upon residues of the insecticides aldrin, chlordane, parathion, and toxaphene are investigated. No experiment dealing with the effect of commercial alfalfa dehydration on these insecticides could be found in the literature. Data are available which deal with residual levels of these insecticides at various intervals after application to alfalfa foliage at rates which are considered to be adequate for good insect control (Ginsburg *et al.* 1949, 1950; Hoskins 1949; Laakso & Johnson 1949; Decker *et al.* 1950).

The analytical picture is complicated by the fact that there exists no directly comparable method of analysis for these four insecticides. The aldrin content can be determined by the use of the more or less specific colorimetric method described by Danish & Lidov (1950) or through the use of methods for the determination of total organic chlorine (Decker *et al.* 1950). The complicated mixture of products known to exist in technical chlordane and technical toxaphene has resulted in the use of methods for the determination of total organic chlorine to establish the residual levels of these two insecticides (Laakso & Johnson 1949; Carter *et al.* 1950; Decker *et al.* 1950). These methods for determining total organic chlorine are not specific however, and the presence of any other chlorine-containing organic compounds will interfere. The sensitive colorimetric method of Averell & Norris (1948) provides the best chemical method for the determination of parathion.

The complexities associated with the various chemical methods of determining residues of the four insecticides used in this study, led to the investigation and adoption of a uniform biological assay method for all the residues. In adopting a biological assay method, the authors realized that the procedural problems involved and the physical and chemical variabilities of four rather different insecticides are no less complicated than in the use of the chemical methods. At best, any comparative study of the residues of the technical grades of these four insecticides, with their divergent chemical and physical properties and their quite different toxicological properties, should have some mutually constant basis of comparison. Such a basis is afforded by employing carefully conducted biological assays. The use of biological assay techniques in entomology is not new; for years, various semiquantitative assay methods have been used principally to evaluate household insecticides and to test the variety of compounds encountered in insecticide screening programs. More recently, biological assay methods have been used by several workers for the quantitative estimation of microgram quantities of residues of the newer insecticides in or on both plant and animal tissue (Laug 1946, 1948; Dahm & Pankaskie 1949; Carter *et al.* 1950; Decker *et al.* 1950; Hartzell 1950; Hartzell & Storrs 1950; Hoskins & Messinger 1950). In utilizing a biological assay method there must be assurance that the toxicity being measured by the use of living organisms is proportionate to the concentration of the toxicant and is not due to some impurity which was removed along with the insecticide during the extraction process. In other words, the toxicity must be due rather completely to the insecticidally active component being measured. That this is actually the case has been demonstrated by several of the users of biological assay methods cited above (Laug 1946; Carter *et al.* 1950; Decker *et al.* 1950).

MATERIALS AND METHODS.—The pro-

[1] Contribution No. 581, Department of Entomology; part of a thesis submitted in partial fulfillment of the requirements for the degree Master of Science in Entomology. This work was supported in part by funds from Kansas Agricultural Experiment Station projects No. 323 (Hatch) and Commercial No. 56 (Julius Hyman and Company, Denver, Colorado).

[2] Present address Phillips Petroleum Co., Bartlesville, Oklahoma.

[3] Graduate student and associate professor respectively in the Department of Entomology, Kansas State College, Manhattan.

cedures used for applying the insecticides, sampling and extracting the alfalfa, and analyzing the residues were essentially the same for the four insecticides. The insecticides were applied to the alfalfa using the following rates and types of formulation: aldrin, 0.5 lb. per acre (25 per cent emulsifiable concentrate); chlordane, 1.5 lb. per acre (74 per cent emulsifiable concentrate); parathion, 0.5 lb. per acre (15 per cent wettable powder); and toxaphene, 2.25 lb. per acre (65 per cent emulsifiable concentrate).

Application was made with a hydraulic sprayer[4] equipped with a 5-foot boom and operated at a pressure of approximately 50 pounds per square inch. The insecticides were applied to the alfalfa immediately ahead of the alfalfa cutter. To avoid contamination of one insecticide with the other insecticides, they were applied to the alfalfa field in the following manner: the alfalfa cutter started at the edge of the field and cut counter-clockwise around the periphery of the field, gradually working its way to the center of the nearly rectangular field. One load was cut and taken to the dehydrator before the first insecticide was applied. The first insecticide was applied and while this load of sprayed alfalfa was being taken to the dehydrator a load of unsprayed alfalfa was cut. This placed a load of untreated alfalfa between each two loads of treated alfalfa.

The standard procedure of dehydrating alfalfa in this part of the United States is to cut and chop the alfalfa in the field. The chopped hay is then blown into a truck and hauled to the dehydrator where it is dumped into an automatic feeder. All operations are automatic after it reaches the dehydrator. The flow of chopped alfalfa through the commercial dehydrator used in this experiment[5] is as follows. The alfalfa is fed into a rotating drum into which is drawn a blast of hot air. The alfalfa traverses the length of the drum three times by means of a moving air stream before being drawn out the opposite end. The temperature at the feeder end of the drum ranges from 900° to 1100° F., depending upon the moisture content of the alfalfa. The temperature at the outlet end of the drum ranges from 250° to 270° F. The dried alfalfa passes through a series of pipes and collectors which cool the alfalfa before it is pulverized by a hammermill and then sacked. The temperatures at the feeder end of the drum, when the sprayed alfafa used in this experiment was dehydrated, were as follows: for chlordane, 952° F.; for aldrin, parathion and toxaphene, 900° F.

The process of cutting, chopping, and blowing the alfalfa into a truck in the field thoroughly mixed the alfalfa. This alfalfa was hauled from the field and dumped upon the empty automatic feeder of the dehydrator. The load was divided by the use of a pitch fork into four parts and large samples of approximately 800 grams each were taken from each part. The time required for alfalfa fed into the rotating drum of the dehydrator to reach the hammermill was approximately 3 minutes. An interval of 5 minutes was allowed from the time sprayed alfalfa started into the drum until samples were taken. The dehydrated samples were taken from a delivery spout just before the dried alfalfa entered the hammermill. By using suitable time intervals, a sample was taken from each of the four parts of the load. Two untreated samples were taken and two untreated, dehydrated alfalfa samples were taken from the same field of alfalfa.

All samples were extracted in the laboratory the same day they were sprayed. The longest period of elapsed time for any sample, from cutting the alfalfa in the field until the time of extraction, was 6 hours. The approximately 800-gram sample of alfalfa was spread on a table, thoroughly mixed and quartered, and a weighed 200-gram portion placed in a 5-quart glass jar. To the jar were added 800 grams of benzene; the jar was sealed and fastened on a rotating extracting machine. The lids of the jars were provided with aluminum foil discs which were replaced each time the lids were used so one insecticide would not contaminate another. The extracting machine had a capacity of eight jars, four on each side, and rotated at the rate of approximately 50 revolutions per minute. The jars were rotated for one hour; then they were removed and the benzene extract filtered into quart fruit jars. The weight of the filtered extract was recorded, then the contents of the extraction jar and the filter were

[4] John Bean Farm Protector model 4-E.

[5] Arnold dehydrator, Heil model SD-8-24; Mfg. by the Heil Co., Milwaukee, Wisconsin.

washed with 100 grams of benzene. The fruit jar containing the benzene extract and the washings was then stored in the absence of light until biological assays could be made.

The moisture contents of 200-gram, well-mixed portions of most of the field samples were determined by drying to constant weight at 105° C. in an electric oven. The average moisture content of the fresh field samples was 70.1 per cent with a range of 1 per cent or less. Therefore, a value of 30 per cent dry weight was used for all calculations involving field samples. The actual sample weights of the dehydrated samples were used in all calculations involving the dehydrated samples.

The benzene extracts of all the samples were decolorized following the procedure of Averell & Norris (1948).

A series of preliminary tests were carried out to establish a uniform method for the biological assays, and the following method was adopted. The insect used throughout these biological assays was the house fly, *Musca domestica* Linn. The flies were reared according to the official NAIDM method.[1] Flies 3 to 4 days old were used in all the tests. Suitable aliquots of the decolorized benzene extracts were evaporated in 100-millimeter diameter petri dishes, by the use of a gentle stream of air. In addition, 1 milliliter of corn oil solution, containing 20 milligrams of corn oil per milliliter of benzene, was added to each petri dish along with the benzene extract to help retain the insecticide residues after the benzene was evaporated. The petri dishes provided an even surface over which the residues could be spread.

Each petri dish then was fitted with a cylindrical screen wire cage which was 3.375 inches in diameter and 8 inches long. Investigations were made as to the effect of confining the flies close to the residue in the petri dish by means of a cardboard disc plunger for periods of 30 minutes, 1 hour, and 2 hours. These tests indicated that very little additional kill was produced by confining the flies close to the residue for more than 1 hour; therefore, the 1-hour exposure period was used in all subsequent tests. Preliminary tests were run also to determine the optimum number of flies to use; the results of these tests indicated that the most consistent results were obtained when approximately 50 flies were used. Therefore, 50 flies consisting of both sexes were used for each biological assay.

Standard or reference solutions of each of the four insecticides were prepared using benzene as the solvent. Predetermined amounts of the decolorized benzene extracts of the field and dehydrated samples as well as predetermined dosages of the standard solution were added to the petri dishes. The benzene from the extracts and the standard solutions was evaporated by using a gentle stream of air; the residues were allowed to stand for 1 hour to help dissipate any traces of benzene. This process of evaporation was aided in the terminal stages by rocking and rotating the petri dish to distribute the residue evenly over the bottom.

After 1 hour, each petri dish was fitted with a cylindrical screen wire cage; a rubber band held the petri dish on the cage. Enough flies for an entire series of assays were collected in a container made by removing the bottoms from two 1-quart cylindrical cardboard containers and taping them together. Each end of the container was provided with a screen lid. The flies were anesthetized with carbon dioxide (Williams 1946) and distributed among 16 pint cylindrical cardboard containers which were provided with screen lids. The flies revived quickly and were checked to make sure none had been injured during the transfer. As flies were needed, each of the pint containers, containing approximately 60 flies, were placed in a can and again anesthetized with carbon dioxide. The container was removed and the flies were poured upon a perforated plastic disc. Regulating the flow of carbon dioxide kept the flies quiet so they could be counted. Fifty flies were counted as they were picked up by an aspirator operating off a vacuum. The flies were then emptied from the aspirator into a test cage. The test cage was set on end and the flies were confined in a small volume, including the insecticide residue, by means of a cardboard disc plunger which was lowered to within 1 inch of the residue on the petri dish.

After 1 hour of such exposure the flies were anesthetized again, the plunger removed, the cage laid on its side, and a

[1] Soap and Sanitary Chemicals Blue Book for 1948.

souffle cup[1] containing sugar water and a cellulose absorbent was placed in the cage. The cage was covered with a screen wire lid. All the cages were placed in a holding cabinet maintained at a temperature of 80° (±2°) F. and a relative humidity of 50 (±5) per cent and held for 48-hour mortality counts.

A series of 15 or 16 assays was run on the same day using a uniform sample of flies and consisting of suitable aliquots from the decolorized benzene extracts of the four field samples of treated alfalfa, the four dehydrated samples of treated alfalfa, a field sample of untreated alfalfa, a dehydrated sample of untreated alfalfa, and five or six dosage levels of the respective standard insecticide solution. The regression of the per cent mortality in probits (Bliss 1934) on the dosage of the standard solution was calculated by the method of least squares. It was found that the regression of mortality expressed as probits on dosage of the standard solution gave the best regression line. By means of trial assays, suitable aliquots of the decolorized benzene extracts of the field samples and dehydrated samples of the treated alfalfa were determined so most of the assays produced a mortality among the flies of between 20 and 80 per cent. The lowest and highest dosages of the standard solution produced mortalities which approximated this mortality range also. The per cent mortality produced by measured volumes of decolorized benzene extracts was always converted to probits, and the corresponding dosage of insecticide obtained either by substitution of this probit value into the regression equation or by reading the dosage directly from the regression line.

The experimental data and calculated regression lines which were used as standards for evaluating the residues of aldrin, chlordane, parathion, and toxaphene are shown in figures 1, 2, 3, and 4 respectively. It was a simple matter to compute the amount of insecticide residue present in the benzene extracts of both the field and dehydrated samples of treated alfalfa and in turn the amount of insecticide residue present on the treated alfalfa itself. The mortality of flies produced by corresponding aliquots of the decolorized benzene extracts of both the field and the dehydrated samples of untreated alfalfa were always negligible. In the case of the field samples of treated alfalfa, the amount of insecticide residue present on the samples was computed for both the dry and wet weight of alfalfa, using the previously determined average values of 70 per cent moisture and 30 per cent dry matter.

RESULTS.—A summary of the effect of alfalfa dehydration upon residue of the four insecticides is shown in table 1. These data are the average results of a minimum of 16 separate biological assays for each field and dehydrated sample of alfalfa treated with each of the four insecticides. Approximately 400 biological assays of benzene solutions containing known and unknown amounts of the four

[1] Lily-Tulip Souffle Cup No. 50PB.

Table 1.—A summary of the effect of alfalfa dehydration upon residues of aldrin, chlordane, parathion, and toxaphene as determined by biological assay with house flies 3 to 4 days old.

INSECTICIDE	FORMULATION	RATE OF APPLICATION	RECOVERY ON ALFALFA[7]		INSECTICIDE RESIDUES			
					Field Samples			
					Based on dry weight of alfalfa	Based on wet weight of alfalfa	Dehydrated Samples	DECREASE IN DEHYDRATED SAMPLES
		lb./A.	*lb./A.*	*Per Cent*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*Per Cent*
Aldrin[1]	25% E.C.[5]	0.5	0.09	18	45	19	14	69
Chlordane[2]	74% E.C.	1.5	0.47	31	233	100	45	81
Parathion[3]	15% W.P.[6]	0.5	0.09	18	43	18	7	84
Toxaphene[4]	65% E.C.	2.25	0.38	17	188	81	64	66

[1,2] Julius Hyman & Company, Denver, Colorado.
[3] Thompson-Hayward Chemical Company, Kansas City, Missouri.
[4] William Cooper & Nephews, Inc., Chicago, Illinois.
[5] E. C. = emulsifiable concentrate.
[6] W. P. = wettable powder.
[7] Based upon an estimated yield of 1 ton of dehydrated alfalfa per acre made by the operator of the dehydrator plant for this particular field of alfalfa.

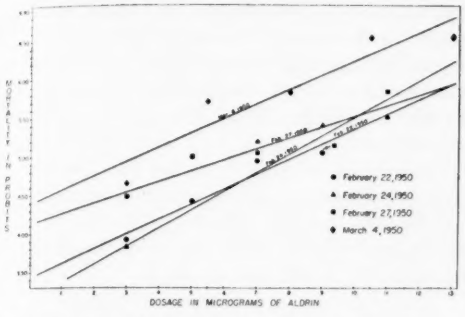


FIG. 1.—Standard regression lines of mortality-probits on dosage of aldrin.

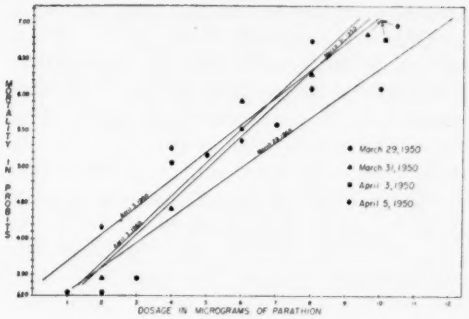


FIG. 3.—Standard regression lines of mortality-probits on dosage of parathion.

insecticides were conducted in the course of obtaining these experimental data.

DISCUSSION.—Although the four insecticides used in this study would be applied normally to alfalfa for the control of insects several days or even weeks before the crop was harvested, it was considered desirable in this experiment to apply the insecticides immediately before harvesting in order to have maximum insecticide residues present on the foliage which was subjected to the commercial dehydration process. Thus our data show the average maximum insecticide residues on the freshly sprayed foliage and the decrease in these residues due to the dehydration process. It seems reasonable, furthermore, to assume that the per cent reductions in residues brought about by the dehydration process under these experimental conditions would be equally applicable to residues which were much older and consequently much lower as the result of weathering, volatization and decomposition.

There are not a great deal of residue data available for these four insecticides applied to alfalfa. In the case of aldrin, Decker *et al.* (1950) report an average value of 13 p.p.m., based upon wet weight of alfalfa and an application rate of 0.25 lb. of actual aldrin per acre. In this case the samples were gathered shortly after spraying, and less than a day elapsed between application and sampling. Under our experimental conditions we obtained average residual values of 45 p.p.m. of aldrin, based upon dry weight, and 19 p.p.m. of aldrin, based upon wet weight, on alfalfa which had been sprayed at the rate of 0.5 lb. of actual aldrin per acre. In the case of chlordane, Decker *et al.* (1950) report an average residue value of 38 p.p.m., based upon wet weight of alfalfa and an application rate of 1.0 lb. of actual chlordane per acre; their samples were taken shortly after spraying. Our average value for chlordane was 100 p.p.m. of chlordane, based upon wet weight of alfalfa which had been sprayed at the rate of 1.5 lb. of actual chlordane per acre.

Residue data for parathion indicate that a heavy application of a 0.5 per cent

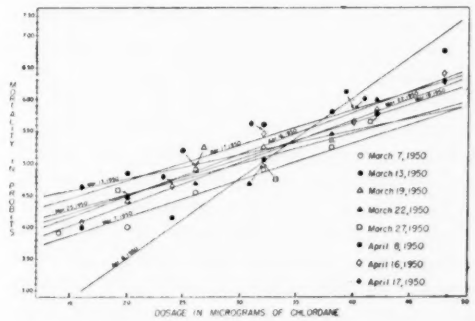


FIG. 2.—Standard regression lines of mortality-probits on dosage of chlordane.

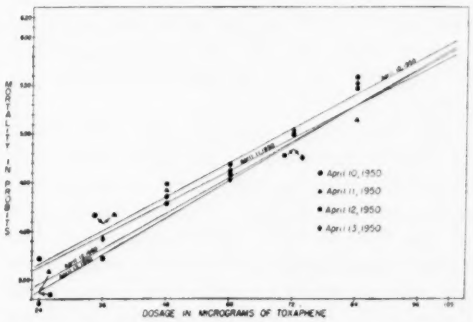


FIG. 4.—Standard regression lines of mortality-probits on dosage of toxaphene.

parathion dust to alfalfa resulted in a parathion residue of 20.4 p.p.m., (Ginsburg *et al.* 1949), and a heavy application of a 1 per cent parathion dust to alfalfa resulted in a parathion residue of 47.2 p.p.m. (Ginsburg *et al.* 1949), and a heavy application of a 1 per cent parathion dust to alfalfa resulted in a parathion residue of 47.1 p.p.m. (Ginsburg *et al.* 1950); in both cases the samples were taken on the day of application of the insecticide and the residue values are based upon wet weight of alfalfa. More recent data (Pankaskie & Dahm 1950[1]) from this laboratory indicate an average parathion residue value of 30 p.p.m., based upon wet weight of alfalfa, for alfalfa samples taken approximately 6 hours after the application of a water emulsion of parathion at the rate of approximately 0.75 lb. actual parathion per acre, and using the Gunther & Blinn (1950) modifications of the Averell & Norris (1948) method. In this experiment we obtained an average value of 43 p.p.m. of parathion based upon wet weight of alfalfa which had been sprayed at the rate of 0.5 lb. of actual parathion per acre.

The residue data of Laakso & Johnson (1949) for toxaphene indicate that on an alfalfa plot which received two applications, 12 days apart, of a water emulsion of toxaphene, at the rate of 2 lb. of actual toxaphene per acre, there was a final field toxaphene residue of 165 p.p.m. based upon wet weight of the alfalfa. Decker *et al.* (1950) report an average residue value of 162 p.p.m. of toxaphene, based upon wet weight of alfalfa, from alfalfa samples taken shortly after the alfalfa was sprayed with toxaphene at the rate of 1.5 lb. of actual insecticide per acre. We obtained an average residue value of 81 p.p.m. of toxaphene, based upon wet weight of alfalfa which had been sprayed with a water emulsion of toxaphene at the rate of 2.25 lb. of actual toxaphene per acre.

All these data confirm the variability of analytical results inherent with this type of work. The agreement between our data and that of other workers, in the case of the field samples, adds interest to the rather significant decreases in residues of all four insecticides following commercial dehydration of the same alfalfa. It is not within the scope of this paper to transpose the insecticide losses due to the dehydration process found in this experiment to the conditions which prevail with regard to insecticide residues of these four insecticides 2 to 4 weeks after their application to alfalfa. That should be another experiment in itself, but it is interesting to speculate on the probable final insecticide residues of these four insecticides in the alfalfa meal which is used in mixed feeds and what these residues might be ultimately in the human diet.

Three points are worthy of mention in connection with the assay procedure. First, it is recognized that the biological assay procedure measures only the insecticidally active portion of the mixture of chemicals present in the technical insecticide product, Second, by employing carbon dioxide anesthesia it is possible to randomize completely the selection of the house flies used as test animals; and third, no great loss of parathion was apparent in our benzene extracts as reported by Gunther & Blinn (1950) for benzene extracts of apple pulp and benzene solutions of orange oil; our benzene extracts of alfalfa were stored in the dark at room temperature in sealed glass quart jars. If any loss occurred it would seem that it should be proportionate in the benzene extracts of both the field and dehydrated samples.

SUMMARY.—In this experiment, a biological assay method was used to determine the effect of commercial alfalfa dehydration upon residues of four insecticides: aldrin, chlordane, parathion, and toxaphene. The alfalfa was sprayed in the field and immediately cut and hauled to the dehydrator where samples of the chopped alfalfa were taken. This same sprayed alfalfa was then run through a commercial dehydrator and the dehydrated samples were collected. The results of over 400 assays show that residues of the four insecticides were reduced considerably by the dehydration process. A water emulsion of aldrin, applied at the rate of 0.5 lb. of actual aldrin per acre, left an average residue of 19 p.p.m. which was reduced an average of 69 per cent by dehydration. A water emulsion of chlordane, applied at the rate of 1.5 lb. of actual chlordane per acre, left an average residue of 100 p.p.m. which was reduced an average of 81 per cent by dehydration. A wettable powder suspension of parathion, applied at the rate of 0.5 lb. of

actual parathion per acre, left an average residue of 18 p.p.m. which was reduced an average of 84 per cent by dehydration. A water emulsion of toxaphene, applied at the rate of 2.25 lb. of actual toxaphene per acre, left an average residue of 81 p.p.m. which was reduced an average of 66 per cent by dehydration. All residue values cited above were based upon the wet weight of the alfalfa.

LITERATURE CITED

Averell, P. R., and M. V. Norris. 1948. Estimation of small amounts of 0, 0-diethyl 0, p-nitrophenyl thiophosphate. Anal. Chem. **20**: 753–6.

Bliss, C. I. 1934. The method of probits. Science **79**(2037): 38–9.

Carter, R. H., R. H. Nelson, and W. A. Gersdorff. 1950. Organic-chlorine determinations as a measure of insecticide residues on agricultural products. Am. Chem. Soc. Advances in Chemistry, Series 1, pp. 271–3.

Dahm, P. A., and J. E. Pankaskie. 1949. A biological assay method for determining aldrin. JOUR. ECON. ENT. **42**(6): 987–8.

Danish, A. A., and R. E. Lidov. 1950. Colorimetric method for estimating small amounts of aldrin (Compound 118). Am. Chem. Soc. Advances in Chemistry, Series 1, pp. 190–7.

Decker, G. C., C. J. Weinman, and J. M. Bann. 1950. A preliminary report on the rate of insecticide residue loss from treated plants. In Press.

Ginsburg, J. M., R. S. Filmer, J. P. Reed, and A. R. Paterson. 1949. Recovery of parathion, DDT and certain analogs of dichlorodiphenyl-dichloroethane from treated crops. JOUR. ECON. ENT. **42**(4): 602–11.

Ginsburg, J. M., R. S. Filmer, and J. P. Reed. 1950. Longevity of parathion, DDT, and dichlorodiphenyl dichloroethane residues on field and vegetable crops. JOUR. ECON. ENT. **43**(1): 90–4.

Gunther, F. A., and R. C. Blinn. 1950. Mass production techniques for estimation of parathion residues. Am. Chem. Soc. Advances in Chemistry, Series 1, pp. 71–87.

Hartzell, A. 1950. Toxicity of spray residue of fresh and processed fruits and vegetables. Am. Chem. Soc. Advances in Chemistry, Series 1, pp. 99–101.

Hartzell, A., and E. A. Storrs. 1950. Bioassay of insecticide spray residues in processed food. Contrib. Boyce Thompson Inst. **16**(2): 47–53.

Hoskins, W. M. 1949. Deposit and residue of recent insecticides resulting from various control practices in California. JOUR. ECON. ENT. **42**(6): 966–73.

Hoskins, W. M., and P. S. Messenger. 1950. Microbioassay of insecticide residues in plant and animal tissues. Am. Chem. Soc. Advances in Chemistry, Series 1, pp. 93–8.

Laakso, J. W., and L. H. Johnson. 1949. Toxaphene residues on alfalfa. Mont. Agr. Expt. Sta. Tech. Bul. **461**: 5–15.

Laug, E. P. 1946. A biological assay method for determining DDT. Jour. Pharmacol. Expt. Therap. **86**(4): 324–31.

Laug, E. P. 1948. Tissue distribution of a toxicant following oral ingestion of the gamma isomer of benzene hexachloride by rats. Jour. Pharmacol. Expt. Therap. **93**(3): 277–81.

Williams, C. M. 1946. Continuous anesthesia for insects. Science **103**(2663): 57.

Importance of Feeding and Defecation Times of Insect Vectors in Transmission of Chagas' Disease

SHERWIN F. WOOD, *Los Angeles City College*[1]

The successful contaminative transmission of the causative agent of Chagas' disease, *Trypanosoma cruzi*, is dependent upon such circumstances as the creation of a bite wound by feeding of the bug and its contamination with infective feces, the defecation of the bug on or near moist mucous membranes of the host, the crushing of the insect's body against that of the host, or contact of the host's skin abrasions with fresh infective insect excreta. Virulence of the transmitted parasite is important in determining subsequent symptoms.

Nocturnal blood-sucking bugs (*Triatoma*, *Paratriatoma*) feed about the exposed, less hairy surfaces, as parts of the face. Oral, nasal and especially ocular mucous membrane contamination may account for the high percentage of facial edemas detected in the diagnosis of the disease. In areas where the nights are hot, there is probably less chance of facial contamination since the bugs can feed readily on other exposed surfaces. Laboratory observations of the writer on guinea pigs, rats and mice do not reveal any special preference for less hairy portions of the body or head of these animals.

Since there is no physical discomfort at time of contact or during feeding, excepting when the proboscis is in close proximity to nerve endings in the skin, there are not likely to be body movements by the host at this time. However, for individuals who are hypersensitive to salivary substances of the bugs (Wood 1950), interrupted feeding of the bugs because of host movements may result from possible irritation at the site of the bite.

Triatomids appear not to remain next to the food source in the laboratory but total feeding time may be important in bringing chance contaminative transmission since the longer it takes to feed, the greater the opportunity for the bug's body to be crushed by movements of the host. Several people have reported finding crushed insects in their beds (Wood 1941, 1942). During the summer of 1950, two *Triatoma protracta* successfully fed on the writer or the writer's wife at the San Joaquin Experimental Range but no reaction was noted. The bugs were found in the morning at the top end of the mattress and in the crack between mattress and box springs at the head of the bed.

An opportunity to check several species under ideal conditions was presented at the San Joaquin Experimental Range, O'Neals, California. The temperature was read in the adobe laboratory building at the time of feeding. Feeding times were recorded for each individual in total lapsed time in minutes and seconds with number of breaks during the feeding process in parentheses. Each record represents a different insect. The following results were obtained:

Triatoma protracta at 83°- F, female, 29:10(2); at 93°- F, female, 5:57(0); male, 9:59(0) and male, 10:25(1). Two timings in the City College laboratory on warm days were as follows: one female, 12:10(0) and another female, 26:00(0).

Triatoma rubida uhleri at 83°- F, female, 21:12(3); female, 5:10(0); female, 17:-50(0); male, 13:23(1); at 85°- F, male, 5:58(0); at 90°- F, female, 4:31(0) and female, 11:28(3).

Triatoma longipes at 94°- F, female, 12:50(1).

Paratriatoma hirsuta at 89°- F, male, 6:00(2) and female, 4:18(3); at 93°- F, female, 2:50(0).

Thus, the contact feeding time ranged from 2 minutes 50 seconds (*Paratriatoma hirsuta*) to 29 minutes 10 seconds (*T. protracta*) for the above examples. The higher temperature probably speeds up the feeding process although the data here are too few to prove it. The different species vary considerably in their total animal contact time during feeding. Temperature probably helps to shorten feeding time through higher metabolic feeding drive of the insect. The first and last female *T. protracta* harbored *Trypanosoma cruzi* but all the other bugs were not infected. All feed-

[1] The writer wishes to express appreciation for use of the facilities at the San Joaquin Experimental Range, O'Neals, California, to the California Forest and Range Experiment Station and the Division of Zoology at Davis, University of California, and to thank Dr. Fae D. Wood for critical reading of the manuscript.

Table 1.—Defecation times of cone-nosed bugs. (Observed at O'Neals except when otherwise noted.)

Species & Sex	Room Temp. °F.	Time to Nearest Minute Fecal Deposit Noted After Blood Meal								Observation Ended
		1	2	3	4	5	6	7	8	
Triatoma protracta[1] ♀	66	15	38	49	59	78	120	152	243	294
T. protracta[1,2] ♂	66	44	94	115	147	264				289
T. protracta ♀	94	0.1	18	24	31	39	55	140		180
T. protracta ♀	94	2	7	24	30	43	57	92	140	180
T. protracta ♀	94	3	30	38	47	55	77	98	117?	152
T. protracta ♀	94	20	38	81						157
T. protracta ♂	94	6	13	26	31	49	68?			103
T. protracta ♂	91	21	38	118	137					180
T. protracta ♂	81	133								180
T. protracta ♂	81	62	125							180
Triatoma uhleri ♂	91	1	9	17	26	32	43	50	69	180(3)
T. rubida uhleri ♀	91	6	9	14	20	32	36?	?	78	180(2)
T. rubida uhleri ♀	91	0.1	10	16	17	25	36	45	56	180(2)
T. rubida uhleri ♀	91	0.5	23	28	33	45	56	66	91	180(1)
T. rubida uhleri ♀	91	0.5	7	19	22	26	34	46	48	180(2)
Triatoma longipes[1] ♂		132								152
T. longipes[1] ♂		32	32	67	72	72	82	117	142	152
T. longipes ♀	94	63	65	73	105					180
Paratriatoma hirsuta ♂	91	25	40	60	63	78	96	129		180
Paratriatoma hirsuta ♂	91	45	45	121	165					180

[1] Observed at City College.
[2] Infected with *Trypanosoma cruzi* Chagas.

ings were on an adult female guinea pig except the first female *P. protracta* at City College which fed from the writer's hand and the second female *T. rubida* which fed on a San Joaquin Cottontail.

Elson (1933)[1] noted that *Triatoma protracta* engorged in 10 to 15 minutes or more on rodents, with 15 minutes continuous feeding usual when feeding on his hand.

Chandler (1949) mentions the importance of insect defecation in relation to transmission of Chagas' disease. Table 1 shows the number of minutes after feeding upon a female guinea pig when bugs voluntarily deposited fecal samples in 50 ml. wide mouth glass isolation bottles. These are all examples of engorged insects. Each timing represents a different insect except the male *Triatoma protracta* at 94°F and the female *T. protracta* at 94° F. from O'Neals mentioned below. Thus, in table 1, the male *T. protracta* at 66° F. and at 94° F. represent two readings on the same bug showing that temperature may stimulate more rapid defecation. However, the female *T. protracta* at 66° F. as mentioned below did not defecate for at least 89 minutes after feeding at 94° F.

In addition to those bugs listed in table 1 there were four *Triatoma protracta* that did not make any deposit during the time interval under observation. One female at 66° F. in the City College laboratory was watched for 223 minutes and one male under the same conditions for 221 minutes. At O'Neals with 94° F. and 91° F. temperatures, respectively, one female (harboring *Trypanosoma cruzi*) did not defecate during 89 minutes and another female for 180 minutes. Since the seconds were recorded for only two female *Triatoma rubida uhleri* and two male *Paratriatoma hirsuta*, the readings are indicated to the nearest minute. Since *Triatoma rubida uhleri* was the only species with 9 to 11 deposits in the 3 hour period, the number of additional deposits is indicated in parentheses after end of observation time. The question marks in the table refer to lack of notation of time, or exact time, when deposit was made by the insect.

From the brief observations recorded, *Triatoma rubida uhleri* is the most important species here studied for immediate contaminative effect since the fully engorged bug tends to deposit immediately and abundantly at short intervals during the first hour after the blood meal. Furthermore, the subsequent total possible

[1] Elson, J. A.—Unpublished thesis, University of California Library.

contaminative effect is greater for this species than for any other here tested. *Triatoma protracta* appears to be a less efficient environmental contaminator, withholding fecal deposits for hours, and therefore would not be as important in contaminative transmission of the parasites of Chagas' disease.

Infection could occur from chance contact of liquid feces with the bite wound, a scratch or open sore of the host on such surfaces as, moist floors of native huts or moist, perspiring skin, where several minutes pass before the liquid evaporates. Undoubtedly, the aridity of the southwestern United States, the small numbers of house invaders, and the low incidence of infection with trypanosomes in the house invading species play an important role in keeping man free of the causative agent of Chagas' disease even though experimental infection of man has been demonstrated with a Texas source of the parasite (Packchanian 1943).

These observations would indicate that chance contaminative contact with the host at time of feeding is more likely for *Triatoma protracta* because of its protracted feeding time but total contaminative effect of bug to host would favor *T. rubida uhleri* because of favorable feeding time and more frequent defecations.

LITERATURE CITED

Chandler, A. C. 1949. Introduction to Parasitology. John Wiley & Sons, Inc., New York.

Packchanian, A. 1943. Infectivity of the Texas strain of *Trypanosoma cruzi* to man. Amer. Jour. Trop. Med. **23**: 309–14.

Wood, S. F. 1941. New localities for *Trypanosoma cruzi* Chagas in southwestern United States. Amer. Jour. Hyg. **34**: 1–13.

Wood, S. F. 1942. Observations on vectors of Chagas' disease in the United States. I. California. Bul. So. Calif. Acad. Sci. **41**: 61–9.

Wood, S. F. 1950. Allergic sensitivity to the saliva of the western cone-nosed bug. Bull. So. Calif. Acad. Sci. **49**: 71–4.

Seasonal Variation in Weight and Ovarian Development in the Worker Honeybee[1]

MARSHALL D. LEVIN and MYKOLA H. HAYDAK, *University of Minnesota, University Farm, St. Paul, Minnesota*

Beekeepers have observed repeatedly that bees of the same stocks often vary in size. Considerable information has also been accumulated regarding variation in structure of honeybees in studies of racial and geographical differences. These have been summarized by Alpatov (1929). Among the structural variations studied were the tongue length, length and width of right wing, number of hooks on hind wing, dimensions of various sternites and tergites, and various measurements of the legs. Variation was also noted between colonies of different strengths, between bees reared in combs with the cell of various sizes, between bees developing from brood kept at different temperatures after sealing, and between bees reared at various times during the season.

Later investigations have shown that there are also variations in body weight and degree of ovarian development as a result of nutritional factors acting during the larval stages of bees. Rhein (1933) was able to produce heavier worker pupae with increased number of ovarioles by feeding large quantities of food to larvae. Nelson & Sturtevant (1924) observed a correlation between weight and rate of development of worker larvae and the amount of nectar brought into the colonies. Haydak (1933, 1935, 1936) reported that the abdomens of worker bees reared on different diets showed more variable protein content than did the other parts of the body. He was not able to determine if this was due to the variable amounts of protein stored in the fat body or to the difference in the development of the ovaries of bees reared in colonies fed different diets.

During any season many factors, such as weather, availability of flowers, strength of colony etc., influence the amount of nectar and pollen brought into the hive. These variations in the food

[1] Paper No. 2618 Scientific Journal Series, Minnesota Agricultural Experiment Station.

Table 1.—Average dry weights of bees from four colonies (in milligrams).

Colony	Whole Bees	Abdomens	Thoraces	Heads	Intestines
A	17.362	2.939	9.023	2.554	2.527
B	17.146	3.182	8.861	2.456	2.516
C	18.355	3.246	9.123	2.591	2.533
D	17.744	3.093	9.305	2.589	2.588

supply may influence the development of the larvae reared at that particular time. Therefore, in the summer of 1948, an investigation was undertaken to find out if seasonal variations exist in the weight and ovarian development of worker bees reared in normal colonies under field conditions.

Four colonies of different relative strengths were maintained at the University Farm Apiary and utilized as the source of bees in this study. Three were overwintered colonies; the fourth was a package newly installed on foundation. The fourth colony was installed on foundation with the purpose of ascertaining what influence, if any, the new combs, having presumably larger cells, would have on the bees reared in them. These experimental colonies are hereinafter designated as follows: Colony A, having only three-quarter frames of brood in the spring, represented the weakest; Colony C, with two and one-half frames of brood, the strongest; Colony B with one and one-half frames of brood intermediate between these two, and Colony D the newly established colony.

Newly emerged bees, 30 minutes to 3 hours old, were collected at approximately 7 to 10 day intervals from combs placed in a constant temperature chamber with the pupae as close to emergence as possible. The first 50 bees collected were killed with chloroform, decapitated, their intestinal tracts removed, and their thoraces separated from their abdomens. Each group of parts was weighed separately and placed in a drying oven. Another 50 bees were killed, weighed, and dried whole. The remaining bees were left in the temperature chamber until it was convenient to do the dissections. The total net weight was divided to obtain the average weight of one bee, one part, etc. This did not permit the calculation of variation between individual bees.

Table 2.—Seasonal variations in the average dry weights of bees from four colonies (grouped sample, in milligrams).

Period	Heads	Intestines	Abdomens	Thoraces	Whole Bees
1	2.435	2.378	3.227	8.875	17.604
2	2.420	2.306	2.915	8.754	16.854
3	2.578	2.594	3.259	9.244	18.120
4	2.550	2.548	3.068	8.974	17.516
5	2.775	2.890	3.219	9.491	18.812
6	2.526	2.529	2.764	9.160	17.007

Table 3.—Seasonal variations in the number of ovarioles of bees from four colonies (grouped samples).

	Colony A		Colony B		Colony C		Colony D	
Period	Left	Right	Left	Right	Left	Right	Left	Right
1	3.1	3.4	3.7	4.0	4.3	4.0	3.3	3.6
2	2.6	3.9	4.0	4.0	3.8	4.0	3.5	4.1
3	4.1	3.8	3.7	3.5	4.9	4.4	3.8	4.4
4	5.1	5.3	3.7	3.5	4.4	4.4	3.5	3.9
5	4.2	3.9	4.0	3.8	4.1	3.7	3.4	3.9
6	4.2	4.4	4.2	4.5	4.4	4.6	4.3	4.3

The data from these samplings were combined in groups to approximate the 21 day developmental cycle of the worker bee. These data were then statistically analyzed.

The number of ovarioles were taken as the criterion of ovarian development The ovarioles were counted by dissecting the bees to expose the ovaries. Under magnification of 45×, the egg tubules of each ovary could be separated and counted without much difficulty.

A scale colony was maintained to provide a weekly record of the amount of nectar brought into its hive. In addition, a normal colony was provided with a pollen trap to supply a record of the amount of pollen available.

The results of this study are presented in tables 1–4.

The colonies were purposely chosen for this work on the basis of their different

Table 4.—Averages of numbers of ovarioles in the ovaries of bees reared in the experimental colonies.

Colony	Ovaries	Mean	Standard Deviation	Number of Bees
A	Left	4.32±0.1257	2.63	438
	Right	4.28±0.2856	5.88	423
B	Left	3.90±0.0949	2.05	467
	Right	3.80±0.0851	1.83	463
C	Left	4.32±0.1019	2.25	488
	Right	4.28±0.1083	2.28	443
D	Left	3.64±0.1047	2.13	414
	Right	3.88±0.1027	2.07	406

relative strengths to see what effect, if any, this factor might have on the data collected (Table 1). The only significant differences were found between the weights of the abdomens of bees from the weakest colony (A), and the two stronger colonies (C and B), and between the weight of whole bees from the strongest colony (C) and that from the two weaker colonies. These differences could be explained by postulating that perhaps the weaker colonies, tending to rear proportionately more brood, had fewer nurse bees, and therefore the larvae were fed less abundantly during the larval period than was the case in the strongest colony. The work of Götze (1930) and Rösch (1925) and Haydak (1933, 1935) would lend support to this explanation. There were no significant differences between weight of bees reared in the new combs of colony D and those reared in the older combs of the overwintered colonies with presumably smaller cells.

All four colonies showed similar peaks in the weight of their bees in the third and fifth developmental periods (Table 2). In order to account for the seasonal variations observed in newly emerged bees, it is necessary to go back to the stage of immature development when affecting factors exert their influence. The egg is laid 21 days before the adult emerges. Three days after deposition it hatches into a larva. During the first two and a half to three days of their lives, all female larvae are fed abundantly. Later the amount of nutritive materials given to worker larvae is restricted. Thus the critical period in the development of the worker bees, as far as the influence of its nutrition is concerned, starts toward the end of the third larval day, and lasts until the cell is sealed, after which time it is given no more food. Therefore it can be assumed that it is within this 3 day period, during which the worker larva is being fed on a restricted diet, that the variation in structure and weight are influenced. On this basis the critical period can be calculated by subtracting 21 days from the emergence date and adding 6 to 9 days, or more simply, it can be taken as 12 to 15 days before emergence.

The uniform seasonal variations between colonies, and in almost all the parts weighed, indicated the influence of some factors common to all the colonies during the critical periods of feeding. These peaks in weight were found to correspond fairly closely to the fluctuation in the amount of pollen brought in by the colony with the pollen trap in the same apiary during the periods in which it was calculated the larvae from which these bees developed were being fed. Todd & Bishop (1946) in California found that the egg laying cycle was strongly influenced by the pollen income, reaching a peak when the pollen income was at a peak, and resulting in a population peak three weeks later.

The very light honey flow during the season in which the present investigation took place did not show any correlation with the seasonal variations in weight just discussed. It is possible that such a correlation might have existed if the honey flow had been much heavier. On the other hand, McGregor (1938) found that the honey flow had no effect on tongue length and wing measurements of the bees reared during the season. He found simultaneous minor variations in these characteristics in the two colonies observed which he attributed to unknown external factors. It is possible that these external factors were fluctuations in the pollen income, which might have been correlated to the variations in the structural characteristics which he investigated in a manner similar to that found in this study.

The correlation between the pollen income and the variations in weight of worker bees has been pointed out. There is not, however, a corresponding correlation with the seasonal variation in the number of ovarioles. However, there is considerable variation in the numbers of ovarioles of the bees reared in the same colony (Table 4). There is no evidence of any significant differences in the number of ovarioles between colonies (Table 4) or during the course of the season (Table 3). The fact that the strongest colony (C) and the weakest (A) have the same average number of ovarioles would justify the statement that the number of ovarioles was independent of any of the factors considered in this study.

The figures presented in tables 3 and 4 are based on more than 1,600 dissections. It was observed that only 19.9 per cent of the bees examined had symmetrical ovaries, while 64.4 per cent had a differ-

ence of from one to three ovarioles between ovaries and 15.7 per cent a difference of more than three ovarioles between ovaries. Hess (1942) found that only 13 per cent of the 40 bees she examined had symmetrical ovaries while 76 per cent had a difference of from one to three ovarioles between ovaries. The appearance of more even numbers of ovarioles than odd, as reported by Hess, was also observed in this investigation.

SUMMARY.—Observations were made on the weight and ovarian development of worker bees reared in four colonies maintained under field conditions.

The seasonal average dry weight of abdomens from bees reared in the weakest colony was lower than that of the abdomens from the two stronger colonies. Also, the average dry weight of whole bees from the strongest colony was higher than that from the two weaker colonies. Thus the strongest colonies are likely to have heavier bees.

With respect to seasonal fluctuations, the dry weights of all parts measured from all the colonies showed similar seasonal variations. These variations were found to correspond fairly closely to fluctuations in the pollen income of a normal colony in the same apiary during the three week period during which it was calculated that the larval stadia of these bees were being fed. No correlation was observed between these seasonal variations and the amount of honey stored by a strong colony on scales in the same apiary.

No differences were observed between the bees reared in the new combs of the package bee colony and those reared in the older combs of the overwintered colonies.

The results of this investigation show no relationship between colony strength and ovarian development, nor were there any seasonal fluctuations in the ovariole numbers which could be considered as not being due to chance.

CONCLUSION.—The dry weights of bees reared in the experimental colonies were influenced by the strength of the colony and by the fluctuations in the pollen income. The number of ovarioles in the ovaries of worker bees reared in the experimental colonies during the season was not affected by these factors. However, there was a considerable variation in the number of ovarioles in the ovaries of worker bees reared in the same colony.

BIBLIOGRAPHY

Alpatov, W. W. 1929. Biometrical studies on variation and races of the honey bee. Quart. Rev. Biol. **4**: 1–58.

Götze, G. 1930. Über den Einfluss der Ernährung auf Beschaffenheit und Leistung der Bienenköniginnen. Bayerische Biene **52**(10): 220–6.

Haydak, M. H. 1933. Der Nährwert von Pollenersatzstoffen bei Bienen. Arch. f. Bienenk. **14**: 185–219.

Haydak, M. H. 1935. Brood rearing by honeybees confined to a pure carbohydrate diet. JOUR. ECON. ENT. **28**: 657–60.

Haydak, M. H. 1936. Value of foods other than pollen in the nutrition of the honeybee. JOUR. ECON. ENT. **29**: 870–7.

Hess, Gertrude. 1942. Über den Einfluss der Weisellosigkeit und des Fruchtbarkeitsvitamins E auf die Ovarien der Bienenarbeiterin. Beihefte zur Schweizerischen Bienenzeitung **I**(2): 33–110.

McGregor, J. E. 1938. Environmental factors and size variation in honeybee appendages. JOUR. ECON. ENT. **31**: 570–3.

Nelson, J. A., A. P. Sturtevant, and B. Lineberg. 1924. Growth and feeding of honeybee larvae. U.S.D.A. Bul. 1222.

Rhein, W. 1933. Über die Entstehung des weiblichen Dimorphismus im Bienenstaate. Wilh. Roux Arch. Entwicklungsmechanic Org. Abt. D. Wis. Biol. **129**: 601–65.

Rösch, G. A. 1925. Untersuchungen über die Arbeitstellung im Bienenstaat. Z.f. Vergl. Physiologie **2**: 571–631.

Todd, F. E., and R. K. Bishop. 1946. Role of pollen in the economy of the hive. U.S.D.A. Bur. Ent. and Pl. Quar. E-536 rev.

Control of the Soil-Inhabiting Grubs of Puerto Rico

GEORGE N. WOLCOTT, *Agricultural Experiment Station, University of Puerto Rico, Río Piedras*

The roots of agricultural crops in Puerto Rico are attacked by two kinds of grubs, either one of which may cause an immense amount of damage if present in appreciable numbers. The common white grubs of the coastal regions are the larvae of *Phyllophaga portoricensis* Smyth, or *P. vandinei* Smyth, endemic maybeetles quite similar in appearance and in the type of injury caused to the white grubs of continental America.

The West Indian weevil root-borer, *Diaprepes abbreviatus* L., has no exact continental counterpart, most adults being considerably larger than the citrus root-weevil, *Pachnaeus litus* (Germar), of Florida. The injury which its legless grubs cause to a plant is mainly from their habit of burrowing to the inside of the subterranean portion and feeding on its interior. Apparently they are quite omnivorous as to the kind of plant attacked, feeding on the roots of abundant weeds and forest trees as well as on economic species, such as mahogany seedlings in nurseries, but have received the name of sugar-cane weevil root-stalk borer because of their principal injury on the main agricultural crop of Puerto Rico.

Despite very heavy larval mortality, survival in sufficient numbers to be a serious economic pest is assured by the five thousand (more or less) eggs which are laid by the females (Wolcott 1936). The legless little grubs, which hatch 7 days after oviposition, appear to have a very tenuous hold on existence, for despite their vigor and constant activity, few of them even attempt to eat, and of the survivors, growth before transformation to second instar is slow as compared with that in the instars immediately following. In the first, second and third instars, the grubs feed on very small roots or on root hairs, showing little or none of the tendency to burrow into the larger roots which appears in the fourth instar. That is, up to the beginning of the fourth instar, they are free-moving in the soil, completely unprotected against any toxic substance which may be present. Thus if any grubs survive in soil to which toxicants have been added, their survival proves that the chemical is not present in sufficient amount to cause mortality.

After the beginning of the fourth instar and up to the time that the grubs have attained full size, they are increasingly protected against the effect of any chemical in the soil by their habit of burrowing inside the grain of corn, or root-stalk of sugar-cane, or comparatively large root or corm or tuber of any plant within which and upon which they may be feeding. In the diapause period before pupation, when they vigorously burrow about through the soil without any apparent purpose, they are again fully exposed to the action of any insecticidal chemical that may be present in the soil, but naturally during this period of their life-history are much more resistant to extraneous chemicals than as just-hatched or very small grubs.

Laboratory experiments conducted with large or fully-grown *Diaprepes* grubs, in the same soil and paralleling similar tests with third (last) instar white grubs of *Phyllophaga portoricensis* Smyth and *P. vandinei* Smyth, in their susceptibility to several of the newer insecticides, gave most inconclusive and indeed at times quite contradictory results. The tests with the third instar white grubs made possible very definite recommendations as to the effective amount per acre to be applied of aldrin, lindane, dichlorodiphenyldichloroethane (TDE), and DDT (Wolcott 1950). Even after being mixed with the soil for a year, both aldrin and lindane showed little or no decrease in toxicity to white grubs, indicating that field applications at the rate of as little as 2 pounds per acre should result in commercial control of this pest.

By comparison, the tests with *Diaprepes* grubs were so unsatisfactory as to suggest that the resistance to chemicals of these grubs in the diapause or prediapause stage is even so much greater than of other grubs of approximately the same size which are still eating and growing. To attain some degree of uniformity, all grubs being tested should be the same instar, presumably insuring that they are approximately of the same susceptibility to toxic substances. The most obvious way of starting with all grubs in the same instar is to use those which

have just hatched. If, despite high larval mortality due to natural causes, some of these can be reared to fourth instar (at which time they cease to be subject to the effect of chemicals mixed with the soil because of their habit of burrowing within the host), this furnishes quite definite proof of the lack of toxicity of the chemical at that rate of concentration in the soil. Admittedly this begs the question of control of large grubs, but as they have already caused most of the injury possible, their destruction is really not as important as that of killing the small grubs before they have begun to burrow into the roots of sugar-cane or other crop.

Oviposition by *Diaprepes abbreviatus* occurs during every month in the year, reaching a maximum during May and June, but because of high parasitism by *Tetrastichus haitiensis* Gahan during these months, it is doubtful if many more grubs reach the soil at this time than when egg-clusters are less numerous. The result is a more or less constant reinfestation of the soil, with no well-defined season when maximum injury from the grubs may be anticipated, to prevent which a toxicant might be applied to the soil. Moreover, few cane growers would thus anticipate damage by *Diaprepes* grubs, but might be expected to apply insecticides after injury had begun to be noticeable, and the specific grubs causing it had already reached their diapause stage. Thus the residual effect of the chemical for some months or years after application on the just-hatched grubs will indicate a more practical method of preventing injury by keeping the soil free of grubs for an extended period, especially if the insecticide is also toxic to white grubs for an equally long time. This extended explanation is given that it may be apparent why the tests about to be described were conducted, and why the methods adopted were used.

One ounce tin salve boxes, and later 2 ounce tin salve boxes, were filled with earth from the much larger cans in which the tests had been conducted with white grubs, in each of which cans the amount of insecticide mixed with the soil was computed on the basis of field applications of pounds per acre. As this soil had been most thoroughly mixed with the insecticide originally, and had been repeatedly mixed subsequently, every time the large cans were dumped for determination of white grub mortality and for replanting with corn, cucumbers and papayas, the small samples of earth extracted for test with the just-hatched *Diaprepes* grubs in the salve boxes may be considered typical. In every case, the results obtained with *Diaprepes* grubs were consistent with each other, indicating that even these small samples contained the proper proportion of insecticide. One grain of corn and four cucumber seeds were planted in the earth in each 1-ounce salve box, and in the 2-ounce tins, four grains of corn. Water was added with a medicine dropper so that the soil would be of optimum moisture content both for the germination of the seeds and for the survival of the grubs. Each day for a week, approximately equal numbers of the *Diaprepes* grubs which had hatched in the preceding 24 hours were placed on the surface of the soil in each salve box. In the later tests, all grubs that hatched in the preceding 24 hours were placed in the cans with earth mixed with different dilutions of only one chemical, so that the date of starting the test might be the same for all. However, to make sure that conditions would be equal for all, subsequent additions might be made when the earth had dried somewhat as the corn germinated. At weekly intervals, or oftener if the corn seedlings tended to push up the cover of the salve box, the entire content was dumped, the presence or absence of grubs noted, their growth and stage of development as indicated by head-size recorded, and grubs and soil replaced, with fresh seeds and an appropriate amount of water added. The tests terminated when at least one grub had reached fourth instar, as indicated by the size of its head capsule, as well as by its change of habit of burrowing into the grain of corn rather than continuing to feed on the roots and root-hairs.

RESULTS.—In the winter rearing experiments (November 1949 to January 1950), by the twenty-seventh day after hatching no live grubs could be found in the earth containing 0.5 aldrin, and by the forty-first day, no live grubs could be in the earth with 1 pound per acre of aldrin. However, one grub in fourth instar, transferred from 1 lb. gamma isomer to 1 pound aldrin, did survive for over 2 weeks, feeding in the corn grain, but having transformed to fifth instar, was dead by

the end of the third week. The only other test resulting in the mortality of the grubs was that containing 10 pounds per acre of TDE, of which some grubs reached second instar 33 days after hatching, but all were dead and covered with spores of the green muscardine (*Metarrhizium anisopliae*) by the forty-first day.

In the winter rearing tests, grubs had transformed to fourth instar by the thirty-third day in the cans containing earth mixed with 1 pound of gamma isomer per acre, and with 1 pound and 2 pounds of chlordan. By the forty-first day, grubs had transformed to fourth instar in 2 pounds of gamma isomer per acre, in 10 pounds of DDT per acre, and in the check. After 47 days, grubs had transformed to fourth instar in earth containing 10 pounds per acre of methoxychlor, 10 pounds of zinc dimethyldithiodicarbamate, 10 pounds CPR (U. S. Industrial Chemicals), and 10 pounds of ryania.

The poor showing of some of these chemicals was not unanticipated, as they had been similarly ineffective against white grubs. But the gamma isomer of benzene hexachloride had been almost as effective as aldrin in killing white grubs, and in May 1950 another series of tests was started to determine the concentration at which gamma isomer would be toxic. As in the winter tests, but more rapidly because of somewhat higher temperatures, all the grubs died in the cans containing earth mixed with aldrin at 5 pounds., 2 pounds, 1 pound and 0.5 pound per acre, none being noted after the second week. By the sixteenth day, no live grubs could be found in the earth containing 10 pounds of chlordan per acre, and by the twentieth day none in the earth with 5 pounds of chlordane However, some grubs in the 1 pound per acre chlordane had successfully transformed to fourth instar by the twentieth day after hatching; by the thirty-second day, some had reached fourth instar in the earth containing 2 pounds chlordan per acre.

During the summer rearing tests, some grubs were still alive in second instar by the nineteenth day after hatching in the earth containing 25 pounds and 20 pounds of DDT per acre, but by the twenty-ninth day all were dead.

By the twenty-fourth day after hatching, grubs in the earth containing 1 pound per acre of gamma isomer of benzene hexachloride had transformed to fourth instar; by the thirty-first day, six grubs had reached fourth instar in the earth containing 5 pounds of gamma isomer per acre, and by the thirty-eighth day, one grub had reached fourth instar in the earth with 10 pounds of gamma isomer per acre.

CONCLUSION.—Gamma isomer of benzene hexachloride is almost as effective in killing third instar white grubs, *Phyllophaga* spp., in Puerto Rico as is aldrin, applications of either at the rate of 2 pounds per acre resulting in commercial control. It is much inferior in causing the mortality of just-hatched weevil grubs of *Diaprepes abbreviatus* L., in laboratory tests, merely delaying the rapidity of development at 10 pounds per acre. Aldrin in all tests killed all *Diaprepes* grubs at 0.5 pound per acre. As neither the amount of gamma isomer necessary to kill *Diaprepes* grubs, nor the maximum amount of aldrin in soil in which they can survive was determined, the disparity in effectiveness of the two insecticides is even greater than these tests indicate.

LITERATURE CITED

Wolcott, G. N. 1936. The life history of *Diaprepes abbreviatus* L. at Río Piedras, P. R. Jour. Agr. Univ. P. R., 20(4): 883–914.

Wolcott, G. N. 1950. The chemical control of white grubs in Puerto Rico. Seventh Congress, International Society of Sugar Cane Technologists, August–September 1950, Queensland, Australia.

DDT for Control of Stable Fly, or Dog Fly, in Northwestern Florida

KENNETH D. QUARTERMAN,[1,2] JOHN D. PARKHURST,[3] and WILLIAM J. DUNN[1]

The introduction of DDT as an insecticide brought about many changes and improvements in spraying techniques and procedures for controlling the breeding of stable flies, *Stomoxys calcitrans* (L.), in beach deposits of marine grasses in northwestern Florida.

For many years prior to 1941 the Gulf coast of northwestern Florida was plagued annually by severe outbreaks of this fly, which is known locally as the dog fly. These outbreaks occurred principally from Mobile, Alabama, eastward to Cedar Keys, Florida, a distance of about 400 miles. They occurred with greatest regularity and severity in the 200-mile section between Pensacola and Carrabelle, Florida.

The source of these outbreaks was unknown until recently. King & Lenert (1936) reported the finding of dog fly breeding in shore deposits of marine algae of the genus *Sargassum* along small inlet beaches. Later investigations by Simmons & Dove (1941), however, revealed that they bred in the shore deposits of several species of marine grass that grow on the bottoms of the partially landlocked bays and sounds found in this area, and that are broken off and washed ashore by strong wind and tidal action.

Coincident with the discovery of the breeding sources of dog flies involved in the annual outbreaks of these pests in this area, the problem changed from one of major economic consideration from the standpoint of livestock and resort interests to one of considerable magnitude from the viewpoint of essential military training activities nearby. During severe outbreaks of dog flies all warm-blooded animals, including man, are attacked by swarms of these vicious biting pests. Thousands of flies frequently attack a single individual, making it impossible for him to conduct normal outdoor activities. Stable flies can bite through ordinary summer clothing, and a satisfactory repellent for personal protection was not available at that time.

The establishment of important military-training bases in the area affected by dog fly outbreaks made it imperative that some protection be provided to personnel assigned to these bases. The painful bites of hundreds of flies on the body distracted the attention and hampered the activities of the men, preventing or seriously handicapping outdoor training activities. Occasionally, the flies collected in the cabins of planes, sometimes interfering with firing and general safety after take-off. Outside recreational activities of army personnel were often prevented, and when flies entered screened barracks and mess halls, they annoyed the men and seriously interfered with rest periods, so that the problem also freqently became one of morale.

In 1941 the U. S. Bureau of Entomology and Plant Quarantine, in cooperation with the U.S. Public Health Service and with funds available to the latter, began control operations designed to prevent these severe outbreaks, using a creosote-diesel oil spray on the grass deposits in which the flies developed (Dove & Simmons 1942). Field tests during the 1941 control program indicated that bay water could be substituted for the diesel oil (Simmons & Dove 1942); therefore, the spray used in the control programs from 1942 through 1944 contained one part of creosote and three parts of water taken from the bays and sounds where work was in progress. Beginning in 1942 funds for the control work were supplied by the U. S. Army Air Forces. The objective of the programs was to protect personnel stationed at Army Air Forces training bases in northwestern Florida from outbreaks of dog flies. The programs were conducted cooperatively by the Bureau of Entomology and Plant Quarantine and the U. S. Public Health Service, with the former agency assuming the responsibility for the field control operations.

Although the control programs during the period 1941 to 44, when DDT was not available, were successful, they were very expensive and entailed numerous operational handicaps. Manpower re-

[1] U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine.
[2] Now with U.S. Public Health Service.
[3] U.S. Public Health Service. Resigned August 10, 1946.

quirements were high, and during these war years the supply of labor for such seasonal work was scarce. The transportation of hundreds of thousands of gallons of creosote over water with small towing and storage facilities was constantly a serious problem. The draft of the heavy spraying units and the shallow waters of the bays and sounds where the control work was carried on frequently made it impossible to operate some units during periods of low tides. These prolonged periods of low tides usually resulted from sustained northerly winds, which also tended to concentrate the dog flies in the control area. As a result, the units were sometimes forced into idleness at the most crucial moments. Large quantities of creosote sprays had to be used, as the grass deposits had to be saturated with the sprays, which controlled the fly breeding by the toxic effect of the creosote on the larvae and pupae. The discomforts of working constantly in the water were further aggravated by frequent creosote burns. Consequently, the results of experimental work in 1944, which indicated that DDT could be used successfully to control dog fly breeding in marine grasses (Blakeslee 1945), were hailed with relief and enthusiasm by project personnel.

CONTROL OPERATIONS WITH DDT.—When the tests in 1944 showed that surface applications of DDT sprays would give satisfactory control of dog fly breeding in bay grasses, and also tended to reduce the population of adult flies as they attempted to oviposit on the treated grass deposits, attention was directed toward developing suitable light equipment which would make it possible to exploit fully the advantages offered by this new treatment. The heavy, ponderous equipment previously used with creosote was obsolete for DDT applications. To take full advantage of the new treatment, equipment was needed which would (1) operate in shallow water as close to shore as possible, (2) move slowly during spraying operations and rapidly between working sites, (3) be capable of transporting the workers safely and quickly over large bodies of water to and from the job, (4) be light enough to be worked clear of sand bars when it became grounded in the shallow water in which it had to be operated, and (5) be capable of rapid movement to sheltered areas in the event of severe storms, which sometimes caused rather serious damage to the heavy creosote units.

After a thorough investigation of many types of equipment it was concluded that the swamp gliders that the Army Air Forces used as rescue boats in shallow waters would be most suitable. These gliders were powered by an airplane engine and steered by means of an air rudder. In the spring of 1945 four 18-foot gliders and one 16-foot glider were obtained on loan from the Army Air Forces. Small sprayers having 100-gallon tanks and a pump output of 6 to 8 gallons of spray per minute were installed in the 18-foot gliders, and a 50-gallon sprayer was placed in the 16-foot glider. The standard water-cooled motor of the sprayer was replaced with a lightweight air-cooled engine. The output of the spray gun was only 3 to 4 gallons per minute, and the excess material discharged from the pump was returned to the sprayer tank through a small pipe in the bottom to help agitate the emulsion. Small corks were used to float the hose when it was necessary to use more than 25-foot leads. These five units were sufficient to handle the necessary control work in 1945.

Because it was difficult to obtain technical DDT in sufficient quantity, practically all the spraying in 1945 was done with a by-product oil from the manufacture of technical DDT. A prepared concentrate containing 70 per cent of DDT isomer by-product oil, 20 per cent of a polymethylated naphthalene,[1] and 10 per cent of an aryl alkyl polyether alcohol,[2] was first used at the rate of 1.67 gallons of concentrate per 100 gallons of finished spray. This quantity was later reduced to 1 gallon of concentrate per 100 gallons of finished spray. Salt or brackish water was taken as needed from the bays and sounds where work was in progress. The finished spray was applied at rates ranging from approximately 100 to 600 gallons of spray per linear mile of grass deposits treated, averaging 202 gallons per mile of grass for the entire season. The surface of the grass deposits was wet thoroughly with the emulsion, a dosage of approximately 400 mg. of DDT per square foot, or its equivalent,

[1] APS-202.
[2] *Triton X-100.*

being deposited on the surface of the grass windrows.

Technical DDT was used during most of the 1946 season. For field use a concentrate was prepared that contained 35 per cent of technical DDT, 60 per cent of commercial xylene, and 5 per cent of the emulsifier, all measurements being made on a weight basis. This concentrate was used at the rate of 1.5 gallons per 100 gallons of finished spray.

The equipment used in 1946 was essentially the same as that used in the previous year except that a continuous spray apparatus was developed, which eliminated the use of the conventional spray tank. The spray apparatus consisted of a small spray pump (4 to 6 gallons per minute) powered by an air-cooled engine, both placed in the bottom of the swamp glider. A pipe extended from the pump intake over the back of the glider and down into the water, the end of the intake pipe being just above the level of the bottom of the glider to prevent damage in case the glider ran aground. A vertical check valve was attached to the end of the intake line extending into the water. A screen box, the lower half of which was composed of several layers of 16-mesh bronze screen wire, was fastened to the back of the glider and surrounded the end of the intake pipe to screen out grass, trash, and sand. A small tank containing the DDT concentrate was mounted on the glider seat, and connected to the pump intake pipe by means of three-eighths inch copper tubing. A horizontal check valve was installed in the intake pipe on each side of the union between the pump intake and the line from the DDT concentrate tank on the glider seat. A short piece of high-pressure spray hose connected the pump by-pass and the intake line between the pump and the point where the line from the DDT concentrate tank joined the pump-intake line. The hose line to the spray gun was attached to the regular discharge opening of the pump.

When the spray gun was opened, water was taken into the pump through the intake line that extended over the back of the glider into the water. Since the pump was operated continuously at a constant pressure of 300 pounds, and the specific gravity of the water and DDT concentrate remained constant, it was easy to regulate the flow of DDT concentrate into the pump intake line to give the desired concentration, by means of a small gas cock. The passage of the mixture of DDT concentrate and water through the intake pipe, pump, and discharge hose produced a satisfactory emulsion. When the spray gun was shut off, the short length of hose from the pump by-pass to the intake line was sufficient to take care of the material in the pump and the liquid continued to circulate through the pump and by-pass hose until the spray gun was opened again and spraying was resumed. The horizontal check valves in the intake line prevented the back flow of spray from the pump when the spray gun was closed, and the vertical check valve at the end of the intake served as a foot-valve to keep the intake line primed at all times.

This apparatus worked efficiently throughout the season. The screened boxes were replaced three times on each unit owing to wear and tear, but this change required only a few minutes. The time previously lost by frequent loading of the spray tank was eliminated, and the increased efficiency of this apparatus made it possible to reduce the number of units in use from 5 in 1945 to only 3 in 1946.

The principal weakness of the glider units was their vulnerability to damage from under-water obstructions. The bottoms were constructed of only three-eighths-inch plywood, and with the heavy load (for the gliders) transported in them, holes were easily punched through the bottoms if the gliders struck submerged stumps, logs, or other obstructions. Several mishaps of that type occurred, but the gliders were quickly patched with

Table 1.—Summary of dog fly control operations, 1941–1946. (Creosote was used in 1941,[1] 1942, 1943 and 1944. DDT was used in 1945 and 1946.)

Insecticide and Year	Spray Units Used	Gallons Applied	Linear Miles of Grass Sprayed	Miles of Shore Line Covered	Total Expenditures
Creosote					
1941[1]	8	208,350	286	702	$ 56,039.46[2]
1942	18	1,222,950	606	922	155,158.17
1943	11	1,148,100	361	562	133,334.71
1944	12	1,830,620	567	927	156,077.13
DDT					
1945	5	214,380	1,060	1,677	57,186.43
1946	3	143,673	1,043	1,925	66,574.35[3]

[1] Figures for this year taken from Dove & Simmons (1942).
[2] Does not include purchase of spray machines, automotive equipment, or part of the boat-barge units used.
[3] Includes purchase of equipment used in 1945 and 1946.

plywood at the working sites. The four-man operating crew was sufficient to turn the glider up on its side at the working site, and the patch was applied to the damaged spot. In each instance work was resumed with only a few hours loss of working time. With the glider operator working at its bow, accidents of this kind were kept to a minimum. The glider engine was operated at idling speed during spraying operations, and aided in moving the unit along.

The increased work performed and the greatly reduced costs of operation resulting from the use of DDT in place of creosote sprays may be demonstrated by comparing the figures for the two types of operations as shown in table 1. Almost twice the quantity of grass was treated in 1945 and 1946 as in any previous year, although the number of spray units in operation was greatly reduced. The total cost of the programs with DDT sprays was reduced to approximately one-third that of the programs where creosote was used, and the cost per mile of grass treated was reduced approximately 80 per cent. The cost figure for 1946 includes expenditures for gliders and other permanent equipment used both in 1945 and 1946. If only the cost of materials used and a proportionate share of the equipment expenditures based on a 5-year depreciation schedule were considered, the cost of the 1946 program would have been in the neighborhood of $45,000.

DOG FLY INCIDENCE 1942 TO 1946.—During 1942 fly counts were made on range and dairy cattle both in the coastal control area and in inland areas not directly affected by the coastal outbreaks. Although the counts on range animals in the coastal areas averaged slightly higher than those on dairy animals in the same areas, they were well correlated and it was concluded that fly counts on diary animals would serve as a satisfactory index of dog fly populations. Counts on dairy animals were made daily on the same animals, in the same places, at approximately the same time of day, and by the same persons. After 1942 counts on dairy animals were adopted as a standard procedure for measuring changes in dog fly populations. Counts were made at one dairy in the center of the coastal area at Panama City, Florida, and at two dairies in the inland areas at DeFuniak Springs and Marianna, Florida, respectively. Beginning in 1944, counts were also made at one dairy in the coastal area west of Pensacola, Florida, where no control work was in progress.

A uniform procedure was followed by all cooperating dairies in making the fly counts. Five cows were selected at each dairy and the adult dog flies were counted daily on these animals when they were brought in for milking. Weather conditions were recorded at the time the counts were made. The data shown in table 2 were obtained from the same dairies throughout the period 1942 to 1946, except at Panama City, where it was neces-

Table 2.—Comparison of stable fly or dog fly incidence (numbers per animal) on dairy animals in coastal control area, coastal noncontrol area, and inland area, Florida, 1942–1946.

	Coastal Control Area Panama City					Coastal Non-Control Area West of Pensacola[2]			Inland Areas DeFuniak Springs and Marianna				
Week Ending	1942	1943	1944	1945	1946[1]	1944	1945	1946	1942	1943	1944	1945	1946
Sept. 1	—	—	0.8	6.8	2.9	—	113.0[3]	149.0[3]	—	—	4.3	2.9	3.6
8	—	8.1	1.2	9.4	10.1	—	276.7[3]	154.7	—	4.3	3.9	3.8	4.3
15	28.2	60.5	1.6	10.2	7.3	—	72.7[3]	12.5	—	2.5	4.0	4.1	3.5
22	33.6	48.1	2.7	6.4	2.7	229.3	23.7	4.4	3.0	4.0	5.2	3.6	2.7
29	13.6	44.6	5.3	5.4	—	—	118.3[3]	4.0	2.5	4.2	4.8	3.2	2.4
Oct. 6	19.7	58.2	4.0	4.0	—	67.0	—[3]	306.7[3]	3.9	4.6	3.0	3.4	2.4
13	16.5	101.5	11.3	4.3	—	153.0[3]	64.5	104.0[3]	4.1	5.1	4.4	3.7	4.0
20	39.7	53.8	27.3	3.4	—	257.0[3]	2.9	67.9	5.0	4.0	3.7	3.9	4.1
27	11.7	60.3	7.8	4.5	—	302.0[3]	5.7	89.5	4.8	3.0	3.4	3.0	3.5
Nov. 3	23.0	57.1	8.2	4.9	—	—	—	19.1	5.2	5.3	3.4	2.0	3.9
10	45.7	20.7	12.9	1.7	—	—	—	5.3	4.3	6.1	3.9	1.9	3.2
17	15.2	2.2	3.8	2.6	—	—	—	3.8	3.6	4.9	3.5	—	3.1
24	32.9	—	1.1	—	—	—	—	—	—	—	2.8	—	—
Dec. 1	5.2	—	—	—	—	—	—	—	—	—	—	—	—
Average for season for weeks counted	24.0	51.6	6.8	5.3	—	194.3[3]	81.1[3]	58.1[3]	4.1	4.2	3.8	3.3	3.4

[1] No counts available after September 22. Dairy was sold and animals were moved inland.
[2] No counts made in this area during 1942 and 1943.
[3] Dog fly populations in the vicinity of this counting station were so high on one or more days of the week that the animals remained in the water or wooded areas and did not return home until after dark, making fly counts impossible. The additional counts during these outbreak periods would have materially increased the average for those weeks and for the season as a whole. There were 6 days in 1944, 19 days in 1945, and 14 days in 1946 on which such fly outbreaks made fly counts impossible at this counting station

sary to change the dairy in 1944. The new dairy selected was comparably situated with respect to exposure to dog flies, and the same personnel continued to make the counts, so that the counts for the 4-year period are considered comparable. This dairy went out of business near the end of September, 1946, and it was not possible to secure another suitable one, as all others in this area had begun to use DDT on their herds and premises.

The control obtained with the DDT sprays (Table 2) was much greater than that previously secured with the more expensive creosote treatments, except in 1944 when control operations were begun earlier than in other years and excellent control was obtained throughout that season. DDT control operations also were begun each year in June or July, as soon as the first grass deposits appeared on shore. In the center of the control areas, when DDT was used, the dog fly population was only slightly higher than normal, as indicated by the counts at inland dairies. The counts at the dairy in the coastal non-control area were not received regularly, but there was ample evidence that dog fly outbreaks would have occurred in the control areas if control work had not been in progress.

In addition to the fly counts on dairy animals, counts were made on soldiers at Tyndall Field, near Panama City, during 1944 and 1945. Five locations were selected, which were generally distributed over the military reservation and were representative of the sites where various types of training activities were in progress. The observation points were located at or near mosquito collection traps or resting stations, which were visited daily. The dog fly counts were made by two soldiers at each location. Each soldier observed the flies present on the other after an exposure of approximately 5 minutes. The total count on both of them at each observation point was recorded. These figures were the equivalent of a count of dog flies on 10 men daily. During the entire 1944 season, a total of only 155 flies was counted on the equivalent of 888 men, and in 1945 only 119 flies on 980 men. These total counts for the season on that large number of men were only a small fraction of the number that would be present on a single individual at one time during an outreak.

When the dog fly control project was in operation, 1941 through 1946, there were no general outbreaks of dog flies in the area under control, and no interruptions in the military training programs because of dog flies.

SUMMARY.—In 1945 and 1946 DDT surface sprays replaced the saturation sprays of creosote and water for the control of dog flies, or stable flies, *Stomoxys calcitrans* (L.), breeding in beach deposits of marine grasses along the shores of bays and sounds in northwestern Florida. A continuous-spray apparatus was developed which eliminated the conventional sprayer tank and tank-loading operation. This apparatus, when installed in a swamp glider, constituted an efficient unit for applying DDT surface sprays on bay grass deposits. The use of DDT and the development of this light, efficient equipment for applying it reduced the cost of the control program to approximately one-third that of previous programs when creosote sprays were used, and gave higher levels of fly control. Throughout the 6-year period when control work was in progress, the objective of protecting Army Air Forces personnel at training bases in northwestern Florida from stable or dog fly outbreaks was successfully accomplished.

LITERATURE CITED

Blakeslee, E. B. 1945. DDT surface sprays for control of stablefly breeding in shore deposits of marine grass. JOUR. ECON. ENT. **38**(5): 548–52.

Dove, W. E., and S. W. Simmons. 1942. Control of stablefly, or "dog fly," breeding in shore deposits of bay grasses. JOUR. ECON. ENT. **35**(4): 582–9.

King, W. V., and Louva G. Lenert. 1936. Outbreaks of *Stomoxys calcitrans* L. ("dog flies") along Florida's northwest coast. Fla. Ent. **19**(3): 33–9.

Simmons, S. W., and W. E. Dove 1941. Breeding places of the stable fly, or "dog fly," *Stomoxys calcitrans* (L.) in northwestern Florida. JOUR. ECON. ENT. **34**(3): 457–62.

Simmons, S. W., and W. E. Dove. 1942. Creosote oil with water for control of the stablefly, or "dog fly," in drifts of marine grasses. JOUR. ECON. ENT. **35**(4): 589–92.

Aldrin and Dieldrin Compared as Grasshopper Poisons

A. V. Mitchener, *The University of Manitoba, Winnipeg*

Grasshopper control on the Canadian prairies has undergone many changes in the past 30 years. New insecticides have been made available and new methods of control have been employed. The never ending search for more effective poisons in formulations that can be applied as easily and as inexpensively as possible, continues. Chlordane in an emulsifiable form in a spray was used in Manitoba as the grasshopper poison in 1949. During the first part of the 1950 season, surplus 1949 stock of chlordane was used. Later in the season an emulsifiable formulation of aldrin was used with excellent results.

The three most injurious species of grasshoppers in Manitoba are the clear-winged grasshopper, *Camnula pellucida* (Scudd.), the two-striped grasshopper, *Melanoplus bivittatus* (Say) and the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.). Experimental work with caged grasshoppers was undertaken in the Department of Entomology in 1950 to determine the relative toxic effects of aldrin and dieldrin on each of these three species. The experiments were designed also to determine approximately the number of days that each of these insecticides remained toxic on seedling oats and on Copenhagen Market cabbage leaves. Finally we hoped to obtain some information on the relative speed of toxic action on each of the three species of grasshoppers.

Materials.—In the first series of laboratory experiments, nymphs of the clear-winged grasshopper were collected in the field and brought to the laboratory where they were confined in cages, 6 by 6 by 3.5 inches. These cages had wooden tops and bottoms and screen on both sides and ends. In the second series of laboratory experiments, adults of the clear-winged grasshopper, the two-striped grasshopper and the lesser migratory grasshopper were collected and brought in from the field and after having been chilled to approximately 40° F. in a large thermostatically controlled refrigerator, were segregated and caged by species.

Methods.—For the experiments with the nymphs of the clear-winged grasshopper, tray-grown young oat plants a few inches high were sprayed with 23 per cent aldrin equivalent emulsifiable concentrate at the rate of 232.6 cc to 5 Canadian gallons (6 U.S. gallons) of water. Other trays of young oat plants were sprayed with 24 per cent dieldrin emulsifiable concentrate at the rate of 236.6 cc to 5 Canadian gallons of water. In each instance the plants were sprayed on July 12 and were wet thoroughly from all angles. No wetting agent was added to the spray. Caged nymphs were fed at 11:00 a.m. on July 13 and on subsequent dates with oat leaves treated respectively with aldrin and dieldrin. Each treatment was replicated four times and used on recently caught hoppers. Unsprayed oat leaves were given also to each group of nymphs. Controls or checks which accompanied each experi-

Table 1.—Aldrin and dieldrin compared for the control of nymphs of the clear-winged grasshopper, *Camnula pellucida* (Scudd.)

Experiment	Date Treated Oat Leaves Fed	Number Days Grasshoppers Fed After Plants Sprayed	Total Grasshoppers Used in the Experiments	Per Cent				
				Live Grasshoppers in Checks 48 Hrs. After Caging	Live Grasshoppers 48 Hrs. After Eating Aldrin Sprayed Leaves	Control for Aldrin	Live Grasshoppers 48 Hrs. After Eating Dieldrin Sprayed Leaves	Control for Dieldrin
	July							
1	13	1	456	89.4	15.5	82.6	1.6	98.2
2	15	3	389	86.8	39.4	54.6	0.0	100.0
3	19	7	432	35.0	19.7	43.7	2.5	92.8
4	24	12	266	42.8	20.5	52.0	0.9	97.9

Table 2.—**Aldrin and dieldrin compared for the control of the adult clear-winged grasshopper, *Camnula pellucida* (Scudd.)**

Experiment	Date Treated Cabbage Leaves Fed	Number Days Grasshoppers Fed After Plants Sprayed	Total Grasshoppers Used in the Experiment	Per Cent				
				Live Grasshoppers in Checks 48 Hrs. After Caging	Live Grasshoppers 48 Hrs. After Eating Aldrin Sprayed Leaves	Control for Aldrin	Live Grasshoppers 48 Hrs. After Eating Dieldrin Sprayed Leaves	Control for Dieldrin
	Aug.							
1	24	1	76	88.5	0.0	100.0	0.0	100.0
2	26	3	76	92.4	0.0	100.0	4.2	95.4
3	28	5	80	67.9	0.0	100.0	0.0	100.0
4	30	7	80	92.4	46.5	49.6	7.7	91.6
	Sept.							
5	1	9	79	96.0	75.0	21.8	0.0	100.0
6	3	11	74	77.3	68.0	12.0	3.7	95.2
7	7	15	90	75.0	56.7	24.4	3.6	95.2
8	9	17	90	79.4	84.4	0.0	79.4	0.0
9	14	22	78	48.0	57.7	0.0	37.1	22.7
10	19	27	94	59.3	66.7	0.0	3.0	94.7

ment were fed on unsprayed oat plants.

In the more extended experiments with the adults of the clear-winged grasshopper, the two-striped grasshopper and the lesser migratory grasshopper, cabbage plants growing in the field were sprayed with 4 ounces of actual aldrin to 40 Canadian gallons (48 U.S. gallons) of water and 2 ounces of dieldrin to 40 Canadian gallons of water respectively. In each instance one heaping teaspoonful of a wetting agent was added to each 2 Canadian gallons of spray material. All plants were sprayed thoroughly on August 23 and poisoned cabbage leaves were removed and fed as needed on the dates indicated in the tables which follow. A control was run for each species for each experiment. Each species fed readily upon the cabbage leaves at all times.

Table 3.—**Aldrin and dieldrin compared for the control of the adult two-striped grasshopper, *Melanoplus bivittatus* (Say)**

Experiment	Date Treated Cabbage Leaves Fed	Number Days Grasshoppers Fed After Plants Sprayed	Total Grasshoppers Used in the Experiment	Per Cent				
				Live Grasshoppers in Checks 48 Hrs. After Caging	Live Grasshoppers 48 Hrs. After Eating Aldrin Sprayed Leaves	Control for Aldrin	Live Grasshoppers 48 Hrs. After Eating Dieldrin Sprayed Leaves	Control for Dieldrin
	Aug.							
1	24	1	75	96.3	13.0	86.5	0.0	100.0
2	26	3	74	100.0	0.0	100.0	0.0	100.0
3	28	5	76	95.8	3.8	96.0	0.0	100.0
4	30	7	79	77.7	36.0	53.6	0.0	100.0
	Sept.							
5	1	9	77	84.0	76.0	9.5	0.0	100.0
6	3	11	77	92.0	7.4	91.9	24.0	73.9
7	5	13	79	28.0	52.0	0.0	0.0	100.0
8	7	15	82	70.3	89.2	0.0	85.2	0.0
9	9	17	84	100.0	96.1	3.9	89.3	10.7
10	14	22	74	92.6	82.5	10.9	33.3	64.0
11	19	27	86	87.1	84.0	3.5	43.3	50.3
12	21	29	81	89.6	96.1	0.0	96.1	0.0

Table 4.—Aldrin and dieldrin compared for the control of the adult lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.)

Experiment	Date Treated Cabbage Leaves Fed	Number Days Grasshoppers Fed After Plants Sprayed	Total Grasshoppers Used in the Experiment	Per Cent				
				Live Grasshoppers in Checks 48 Hrs. After Caging	Live Grasshoppers 48 Hrs. After Eating Aldrin Sprayed Leaves	Control for Aldrin	Live Grasshoppers 48 Hrs. After Eating Dieldrin Sprayed Leaves	Control for Dieldrin
	Aug.							
1	24	1	71	100.0	21.7	78.3	0.0	100.0
2	26	3	80	92.6	19.2	79.2	3.7	96.0
3	28	5	82	93.7	13.6	85.4	0.0	100.0
4	30	7	87	77.4	44.8	42.1	0.0	100.0
	Sept.							
5	1	9	82	90.0	35.7	60.3	4.1	95.4
6	3	11	81	88.8	64.5	27.4	17.3	80.5
7	7	15	83	92.0	97.0	0.0	54.1	41.2
8	9	17	85	100.0	96.5	3.5	84.0	16.0
9	14	22	76	88.9	100.0	0.0	54.1	39.1
10	17	25	71	81.4	72.7	10.6	27.2	66.5
11	19	27	75	84.2	89.7	0.0	77.7	7.7
12	21	29	89	100.0	90.9	9.1	60.0	40.0

In computing the percentage of grasshoppers killed by each insecticide for each experiment, the formula (Abbott 1925) $100((x-y)/x)$ was used. Here x is the percentage of live grasshoppers in the control cage and y the percentage of of live grasshoppers in the treated cage. The result indicates the percentage of grasshoppers killed by the poison.

RESULTS.—Table 1 shows the results of the effects of aldrin and dieldrin upon the nymphs of the clear-winged grasshopper at various intervals up to 12 days after the oat plants had been sprayed. Table 2 indicates the relative effectiveness of aldrin and dieldrin on adult clear-

Table 5.—Aldrin and dieldrin compared for the control of three species of grasshoppers.[1]

Experiment	Date Treated Cabbage Leaves Fed	Number Days Grasshoppers Fed After Plants Sprayed	Total Grasshoppers Used in the Experiment	Per Cent				
				Live Grasshoppers in Checks 48 Hrs. After Caging	Live Grasshoppers 48 Hrs. After Eating Aldrin Sprayed Leaves	Control for Aldrin	Live Grasshoppers 48 Hrs. After Eating Dieldrin Sprayed Leaves	Control for Dieldrin
	Aug.							
1	24	1	222	94.8	11.4	87.9	0.0	100.0
2	26	3	230	94.8	6.5	93.1	2.6	97.2
3	28	5	238	85.7	5.3	93.8	0.0	100.0
4	30	7	246	82.1	43.2	47.4	2.5	96.9
	Sept.							
5	1	9	238	90.0	61.7	31.4	1.3	98.5
6	3	11	232	86.4	46.9	45.7	14.6	83.1
7	7	15	255	78.5	81.5	0.0	22.7	71.0
8	9	17	259	93.3	91.9	1.5	84.1	9.8
9	14	22	228	77.2	81.0	0.0	41.3	46.5
10	19	27	255	76.6	79.3	0.0	38.4	49.8
11	21	29	170	95.0	93.2	1.8	78.4	17.4

[1] *Camnula pellucida* (Scudd.)—clear-winged grasshopper.
Melanoplus bivittatus (Say)—two-striped grasshopper.
Melanoplus mexicanus mexicanus (Sauss.)—lesser migratory grasshopper.

Table 6.—**Relative effectiveness of aldrin and dieldrin 24 hours and 48 hours, respectively, after each species of adult grasshoppers had eaten treated cabbage leaves.**

EXPERIMENT	SPECIES	DAYS ADULT GRASSHOPPERS FED AFTER PLANTS SPRAYED	PER CENT KILLED BY ALDRIN		PER CENT KILLED BY DIELDRIN	
			Hours After Feeding			
			24	48	24	48
1	*Camnula pellucida*	1	73.9	100.0	96.0	100.0
2	*Camnula pellucida*	3	84.0	100.0	78.3	95.4
3	*Camnula pellucida*	5	83.4	100.0	95.5	100.0
1	*Melanoplus bivittatus*	1	45.8	86.5	87.5	100.0
2	*Melanoplus bivittatus*	3	40.0	100.0	64.0	100.0
3	*Melanoplus bivittatus*	5	31.8	96.0	67.9	100.0
1	*Melanoplus mexicanus mexicanus*	1	52.2	78.3	82.7	100.0
2	*Melanoplus mexicanus mexicanus*	3	0.1	79.2	61.5	96.0
3	*Melanoplus mexicanus mexicanus*	5	15.4	85.4	96.3	100.0

winged grasshoppers at intervals up to 27 days after the cabbage plants had been sprayed. Table 3 shows the comparative effects of these two insecticides on the adult two-striped grasshopper. Similarly table 4 indicates the effects of the insecticides on the adult lesser migratory grasshopper. Table 5 was computed for all three species from all the results and is not an average of tables 2, 3 and 4. Table 6 compares the percentage of dead adult grasshoppers for each of the three species, 24 hours and 48 hours after each species had been given treated cabbage leaves.

DISCUSSION.—Although every effort was made to spray very thoroughly all parts of the plants to be used subsequently, it is possible that some portions of the leaves may have been missed or sprayed lightly. This may account in part at least for some of the irregularities in the results. Table 1 shows that dieldrin gave excellent control of the nymphs of the clear-winged grasshopper up to 12 days after the oat plants had been sprayed. Aldrin gave fair control when plants were fed one day after the spray had been applied but quite unsatisfactory control thereafter. Table 2 shows that dieldrin gave excellent control of adult clear-winged grasshoppers when they were fed on cabbage leaves which had been sprayed as long as 15 days previously while aldrin gave control similarly for 5 days. Table 3 shows that dieldrin gave almost complete control of adult two-striped grasshoppers with the exception of experiment 6, up to 13 days after the leaves had been sprayed. Aldrin gave satisfactory control only up to 5 days. Table 4 shows similarly that the adults of the lesser migratory grasshopper were controlled up to 9 days with dieldrin and fairly satisfactorily with aldrin up to 5 days. As all three species may at times be involved in an outbreak in a given area all results were averaged using all the available original data in table 5. This table shows that dieldrin is a much more persistent poison than aldrin. Dieldrin was very effective up to 9 days. Aldrin was reasonably effective for 5 days although less effective even though it was applied at twice the concentration of dieldrin.

Although no data were collected to support this viewpoint, our observations indicated that a given number of adult two-striped grasshoppers ate much more food than the same number of either of the other species. This may be of practical interest to the farmer.

Table 6 shows the percentage of each of the three species of grasshoppers that was killed by aldrin and by dieldrin in 24 hours and in 48 hours repectively for three experiments with each species. The table indicates that with the conditions prevailing for these experiments dieldrin acts more quickly than aldrin on each of the three species. The full effects of each poison should not be expected for about 48 hours after the grasshoppers have fed. The clear-winged grasshopper succumbs to both aldrin and dieldrin more quickly

than either of the other two species.

CONCLUSIONS.—1. The clear-winged grasshopper, the two-striped grasshopper and the lesser migratory grasshopper were killed readily with aldrin or dieldrin when each of these was used in a spray on oats and on cabbage.

2. Dieldrin at the rate of 2 ounces to 40 Canadian gallons (48 U.S. gallons) of water, gave better kills than aldrin at 4 ounces to 40 Canadian gallons of water for each of the three species of grasshoppers.

3. Dieldrin was effectively toxic for approximately 11 days on all sprayed plants while aldrin was similarly effective for approximately 5 days on the cabbage plants when results were compared 48 hours after the grasshoppers had fed. Oat leaves sprayed with aldrin were not similarly effective.

4. The data indicate that the clear-winged grasshopper succumbs more quickly to either aldrin or dieldrin than either of the other two species.

5. Maximum kills may be expected about 48 hours after the grasshoppers have eaten the poisoned plants.

6. A household detergent was used effectively as a spreader or wetting agent for the spray that was applied to cabbage leaves.

ACKNOWLEDGMENTS.—The author wishes to acknowledge financial assistance from Julius Hyman and Co., Denver, Colorado who also supplied the aldrin, sample No. 5330, and the dieldrin, sample No. 5333, used in this investigation. He also acknowledges the assistance of Messrs. Peter Bergen and W. H. Foott, student assistants, who collected the grasshoppers and separated the species.

LITERATURE CITED

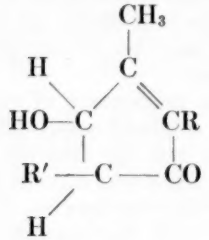
Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. JOUR. ECON. ENT. **18**(2): 265–7.

Relative Toxicity of Allethrin Analogs to House Flies

W. A. GERSDORFF and NORMAN MITLIN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

A number of synthetic compounds of the pyrethrin type have been prepared (Schecter *et al.* 1949), and their toxicity to house flies by the turntable method has been studied (Gersdorff 1949*a*, *b*). Emphasis has been placed on the effect of changes in the structure of the cyclopentenolone component of the compounds, especially in its side chain. One of these materials, now known as allethrin, is being produced commercially as an insecticide. It is the ester of *dl*-2-allyl-4-hydroxy-3-methyl-2-cyclopenten-1-one with a mixture of *cis* and *trans dl*-chrysanthemum monocarboxylic acids.

Recently a group of analogous compounds differing only in the chemical nature of the acidic component were pre-



Compound	R	R′
a	$\cdot CH_2 \cdot CCl{:}CH_2$ (2-chloroallyl)	H
b	$\cdot CH_2 \cdot CH{:}CHCl$ (3-chloroallyl)	H
c	$\cdot CH_2 \cdot CH{:}CCl \cdot CH_3$ (3-chloro-2-butenyl)	H
d	$\cdot CH_2 \cdot C{:}C \cdot CH_3$ (2-butynyl)	H
e	$\cdot CH_2 \cdot CH{:}CH_2$ (allyl)	$\cdot CH_2 \cdot CH{:}CH_2$

pared and evaluated (LaForge *et al.* 1950). In addition five esters were prepared that differed only in the side chain of the keto-alcoholic component, the acidic component being the same (Schechter *et al.* 1950). These esters were evaluated as potential insecticides by comparing their toxicity with that of natural pyrethrins, and the effect of changes in chemical structure on toxicity was determined.

MATERIALS.—Five substituted cyclopentenolones were first prepared. Their structural relationship is shown by the following general formula, the differentiating groups being indicated separately.

These cyclopentenolones were acylated with a mixture of *cis* and *trans dl*-chrysanthemum monocarboxylic acids and the products purified. Although each preparation is acutally a mixture of two geometric isomers, in this paper it will generally be referred to as a single ester. Sprays were prepared by dissolving the esters in refined kerosene at several concentrations.

The standard of comparison was prepared from a kerosene extract of pyrethrum flowers, chemical analysis (Seil method) of which showed that 54 per cent of the total pyrethrins consisted of pyrethrin I and cincerin I. Sprays at several concentrations of pyrethrins were made with this standard.

EVALUATION OF RELATIVE TOXICITY.—Evaluation of the relative toxicity of these esters was made against laboratory-reared adult house flies, *Musca domestica* L., by the turntable method. Knockdown and mortality were determined in replicated tests with the prepared sprays. Approximately 100 flies, averaging 2 days in age, were used in each test.

Since all the compounds could not be tested against the same populations of flies, the tests were made in several series. However, relative toxicity in the different series was placed on a comparable basis by the inclusion of the pyrethrins standard in each.

The mortality data are summarized in table 1. Knockdown of flies was complete, or nearly so, for all the compounds at the concentrations used.

To put the results on a quantitative basis, those in series 2 to 4 were plotted on log-probability paper, and straight lines were fitted graphically. The concentrations causing 50 per cent mortality were estimated from these lines. Relative toxicity as compared with the pyrethrins standard was then expressed as the inverse ratio of these concentrations. The calculations are given in table 2.

Table 1.—Mortality of house flies treated with certain allethrin analogs with different substituent groups in the keto-alcoholic component.

Series	Replicates	Substituent Group	Concentration	Mortality in 1 Day
	Number		*Mg. per ml.*	*Per cent*
1	2	2-Butynyl	16	100
			8	100
			4	85
		3-Chloroallyl	8	100
			4	83
		2-Chloroallyl	16	100
			8	99
		3-Chloro-2-butenyl	16	75
			8	42
		Diallyl	8	75
			4	41
		Pyrethrins standard	4	81
			2	52
			1	25
2	6	2-Butynyl	8	73
			4	48
			2	24
			1	7
		3-Chloroallyl	4	82
			2	45
			1	12
		2-Chloroallyl	4	86
			2	52
			1	14
		Pyrethrins standard	8	87
			4	63
			2	30
			1	9
3	5	3-Chloro-2-butenyl	16	68
			8	26
		Pyrethrins standard	8	92
			4	78
			2	35
			1	12
4	6	Diallyl	8	63
			4	27
		Pyrethrins standard	8	90
			4	74
			2	36
			1	12

EFFECT OF CHANGES IN CHEMICAL STRUCTURE.—It has been shown (Gers-

dorff 1949*a*, *b*; LaForge *et al.* 1950) that there are differences in the relative toxicity of isomers of certain pyrethroids whose only structural difference is manifested by optical activity in the acid component. The esters tested in the present study were prepared from the same acid mixture that is used in the preparation of allethrin. Therefore, to show the effect of the changes in chemical structure on toxicity, the toxicity of the esters was compared with that of allethrin. A number of comparisons by this method, two of which have been reported (Gersdorff 1949 *b*), have shown allethrin to be about three times as toxic as the same natural pyrethrum standard. On this basis certain relationships may be noted.

The introduction of one chlorine atom into the allyl side chain (*a* and *b*) gave compounds about half as toxic as allethrin. No difference in toxicity was demonstrated whether the attachment was on the second or third carbon atom.

The introduction of a chlorine atom at the third carbon atom in the 2-butenyl side chain (*c*) gave an ester about 7 per cent as toxic as allethrin. The effect of this introduction was probably not greatly different from that found for the compounds with the allyl side chain. The corresponding chlorine-free ester—*i.e.*, the ester of the 2-butenyl cyclopentenolone and the mixture of *dl-cis* and *dl-trans* acids—has not been prepared. In a previous study the individual *dl* acid isomers of the ester were found to be 0.39 as toxic as a pyrethrum standard similar to the one used in this study, whether the acid had the *cis* or the *trans* form (Gersdorff 1949*a*). However, the error in this evaluation may be greater than usual because of the possibility of an appreciable error in the concentration measurements. The available amounts of the *dl-cis* and *dl-trans* forms of the acid[1] were so very small that it is possible the resulting esters were not of high purity.

The question of the purity of all four esters prepared from these two acids has arisen for another reason. Allethrin, having as the acidic component the mixture of *dl-cis* and *dl-trans* forms, was one-half as toxic as the corresponding ester of the *d-trans* acid (Gersdorff 1949*b*). In accord with this finding, the ester of the *l-trans* acid was much less toxic than its isomers (LaForge *et al.* 1950). Although allethrin was three times as toxic as pyrethrin standards prepared from pyrethrum extracts from three different sources, the isomers of allethrin with the individual *dl-cis* and *dl-trans* acidic components were only twice as toxic (Gersdorff 1949*a*). This lower value is probably due to the impurity of these two esters rather than to synergistic action when the two are mixed. It is probable, then, that the toxicity ratio of 0.39 for the esters of the 2-butenyl cyclopentenolone with the individual acids is lower than for the corresponding mixed esters.

Table 2.—Relative toxicity to house flies of certain allethrin analogs with different substitutent groups in the keto-alcoholic component as compared with natural pyrethrins.

Series	Substituent Group	Concentration Causing 50 Per Cent Mortality	Relative Toxicity
		Mg. per ml.	*Per cent*
2	2-Butynyl	4.27±0.30	73± 7
	3-Chloroallyl	2.18±0.17	142±15
	2-Chloroallyl	1.99±0.16	156±16
	Pyrethrins standard	3.10±0.21	100
3	3-Chloro-2-butenyl	12.1 ±1.3	21± 3
	Pyrethrins standard	2.51±0.19	100
4	Diallyl	6.30±0.61	41± 4
	Pyrethrins standard	2.60±0.18	100

Another estimate may be made. The relationship between the isomers for the esters having the allyl side chain is probably the same as for the esters having the 2-butenyl side chain. The ester of this group prepared from the mixture of *dl-cis* and *dl-trans* acids would then be half as toxic as the corresponding ester of the *d-trans* acid (Gersdorff 1949*a*)—*i.e.*, one-half of 1.48, or 0.74, the toxicity of pyrethrins.

Thus, two toxicity ratios have been estimated for this ester, 0.39 and 0.74, or relative toxicities of 39 and 74 per cent. Comparison of these values with the corresponding chlorinated ester, 21 per cent (table 2, series 3), shows that the introduction of the chlorine atom into the 2-butenyl side chain has decreased the toxicity by 50 to 70 per cent.

The ester with a triple bond in the side chain of the cyclopentenolone component (*d*) was about one-fourth as toxic

[1] These acids were furnished by S. H. Harper of London.

as allethrin. The chemical change from the 2-butenyl side chain to the 2-butynyl side chain resulted in no loss of toxicity. There appears to be an increase in relative toxicity from 39 to 73 per cent if the relative toxicities for the separate forms of the 2-butenyl ester are used. However, these estimates for these forms may be low, as discussed above.

The introduction of an allyl side chain in position 5 of the cyclopentenolone nucleus (*e*) in addition to the one already present in allethrin in position 2 gave an ester only about 14 per cent as toxic as allethrin.

SUMMARY.—The relative toxicity to house flies, *Musca domestica* L., of synthetic compounds related to allethrin was evaluated by the turntable method, and the effect of changes in chemical structure on toxicity was ascertained.

Two compounds, each with one chlorine atom introduced into the allyl side chain characteristic of allethrin, were one and one-half times as toxic as pyrethrins. No difference in toxicity was demonstrated whether the attachment was on the second or third carbon atom.

A compound with a chlorine atom introduced at the third carbon atom in the 2-butenyl side chain was one-fifth as toxic as pyrethrins.

A compound with a triple bond in the side chain (2-butynyl) of the cyclopentenolone component was about three-fourths as toxic as pyrethrins.

A compound with an allyl side chain attached to the carbon atom in position 5 of the cyclopentenolone nucleus as well as in position 2 was about two-fifths as toxic as pyrethrins.

LITERATURE CITED

Gersdorff, W. A. 1949a. Toxicity to house flies of synthetic compounds of the pyrethrin type in relation to chemical structure. JOUR. ECON. ENT. **42**: 532–6.

Gersdorff, W. A. 1949b. Toxicity to house flies of new synthetic pyrethroid. Soap and Sanit. Chem. **25**(11): 129, 131, 139.

LaForge, F. B., W. A. Gersdorff, Nathan Green, and M. S. Schechter. 1950. Allethrin-type esters of cyclopropane carboxylic acids. I. Amer. Chem. Soc. Jour. (In press).

Schechter, Milton S., Nathan Green, and F. B. LaForge. 1949. Constituents of pyrethrum flowers. XXIII. Cinerolone and the synthesis of related cyclopentenolones. Amer. Chem. Soc. Jour. **71**: 3165–73.

Schechter, Milton S., Nathan Green, and F. B. LaForge. 1950. Constituents of pyrethrum flowers. XXIV. Synthetic *dl-cis* cinerolone and other cyclopentenolones. Amer. Chem. Soc. Jour. (In press).

Starch and Other Carbohydrates in Relation to Powder-Post Beetle Infestation in Freshly Harvested Bamboo

H. K. PLANK and R. H. HAGEMAN, *Federal Experiment Station, Office of Experiment Stations, U.S.D.A., Mayaguez, Puerto Rico*

The concentration of starch in freshly harvested bamboo wood, as indicated by the intensity of the reaction to the iodine spot test, has been correlated to a highly significant degree with the attack of adults of the bamboo powder-post beetle, *Dinoderus minutus* (F.), (Plank 1950). However, the actual amounts of starch and other carbohydrates present were not determined. The purpose of the work reported here was to obtain this information and correlate it with the corresponding iodine spot test reaction and beetle infestation.

MATERIALS AND METHODS.—The culms used in this study varied from 1 to 5 years in age and were harvested from well-established clumps of five species of bamboo: *Bambusa longispiculata* Gamble ex Brandis, *B. polymorpha* Munro, *B. vulgaris* Schrad. ex Wendl., *Dendrocalamus strictus* Nees, and *Sinocalamus oldhami* (Munro) McClure. The day following harvest, one internode was cut from the base, middle, and top positions in each culm and sawed into three-quarter-inch sample rings. Samples of one ring each were taken at random from each of these internodes for estimation of starch concentration by the iodine spot test, according to methods previously described (Plank 1950). The remaining rings were documented according to the iodine-starch score of the internode from which they

Table 1.—Powder-post beetle attacks and carbohydrates in freshly harvested bamboo wood corresponding to different intensities of reaction to the iodine spot test at time of exposure to infestation.

Iodine-Starch Score-Points	Samples Analyzed	Beetle Attacks, Average[2]	Analysis of Wood, Average[1]			
			Starch	Starch+Reducing Sugars	Hydrolyzable Carbohydrates	Dry Matter
Number	*Number*	*Number*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
0	2	0	0.24	0.26	9.26	62.50
1	3	1.67	.70	.79	8.70	64.27
2	3	2.83	1.96	2.03	14.15	66.07
3	3	19.00	2.87	2.96	15.84	72.43
4	3	26.33	5.29	5.50	18.61	70.90
5	3	53.33	6.24	6.39	19.54	71.37
6	3	60.00	8.06	8.27	20.69	74.93
7	1	50.00	7.55	7.71	19.15	76.10

[1] Based on weight at time of exposure to beetle infestation.

[2] Per 4 rings for each sample analyzed.

came and divided at random into two groups. One of these groups was exposed in a standardized cage test to infestation by adults of the bamboo powder-post beetle. The other group was immediately prepared for carbohydrate analysis. A.O.A.C. methods were used to determine starch by taka-diastase hydrolysis, reducing sugars, and insoluble hydrochloric-acid-hydrolyzable carbohydrates.[1]

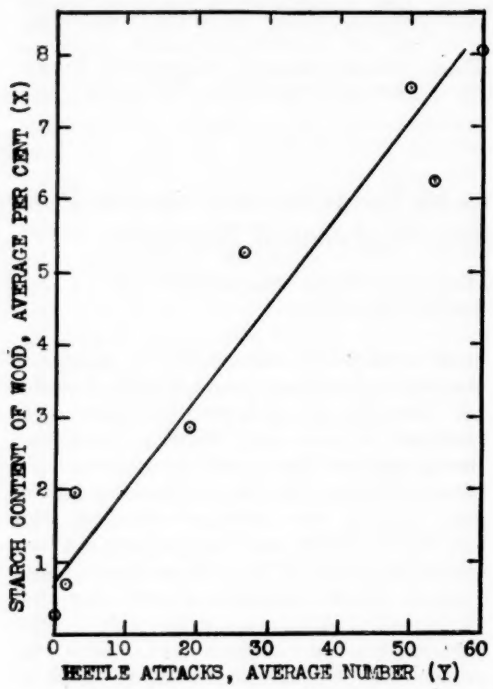


FIG. 1.—Regression of powder-post beetle attacks (Y) on starch content of freshly harvested bamboo wood (X) at time of exposure to infestation. $\hat{Y}=26.65+7.826(X-\bar{X})$ attacks.

RESULTS.—The results of the analyses, averaged by score points, are shown in table 1, along with the corresponding number of beetle attacks recorded from the cage test.

A strong positive correlation is evident in table 1 between iodine-starch score and beetle attacks, starch, starch+reducing sugars, and hydrolyzable carbohydrates, and also between these analyses and beetle attacks. Following are the corresponding

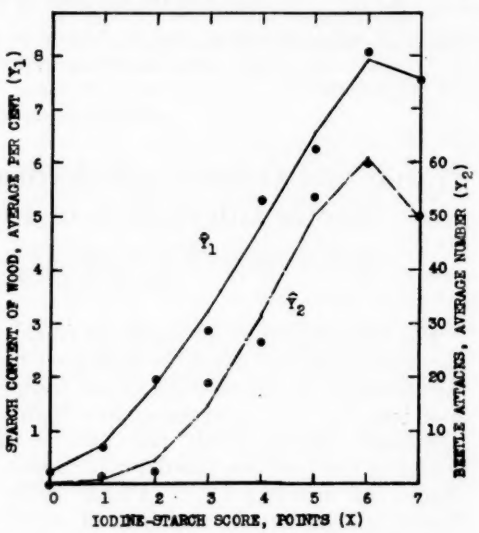


FIG. 2.—Regression of starch content of freshly harvested bamboo wood (solid line, $\hat{Y}_1$) and powder-post beetle attacks (broken line, $\hat{Y}_2$) on iodine-starch score (X) at time of exposure to infestation. $\hat{Y}_1=4.11+0.614z_1-0.013z_2-0.087z_3-0.017z_4-0.004z_5$ per cent. $\hat{Y}_2=26.65+4.76z_1+0.0985z_2-1.20z_3-0.34z_4$ attacks.

[1] Association of Official Agricultural Chemists 1945, pp. 132–4, 410, 411.).

coefficients of correlation and regression, all of which were highly significant by the usual respective "t" and analysis-of-variance tests:

Comparison	Coefficient	
	Correlation	Regression
Iodine-starch score *vs.* beetle attacks	0.939	9.530
Iodine-starch score *vs.* starch	.979	1.229
Iodine-starch score *vs.* starch+reducing sugars	.978	1.252
Iodine-starch score *vs.* hydrolyzable carbohydrates	.924	1.763
Starch *vs.* beetle attacks	.967	7.826
Starch+reducing sugars *vs.* beetle attacks	.966	7.666
Hydrolyzable carbohydrates *vs.* beetle attacks	.898	4.780

Since there was little difference in correlation and regression between comparisons involving starch and starch+reducing sugars, it is evident that reducing sugars were an unimportant factor in influencing infestation by the adults of this insect. Hydrolyzable carbohydrate content (starch+pentosans, some celluloses, etc.) was a good indicator of beetle attack but less accurate than starch alone.

The linear regression of beetle attacks on starch is shown in figure 1, actual values being represented by small circles. It is apparent that severity of attack by the adults of the bamboo powder-post beetle was governed directly by the starch content of the wood at the time of exposure to infestation.

Calculated regression lines most closely fitting the data recorded for beetle attacks and for starch on iodine-starch score are presented in figure 2, with the respective values indicated by heavy dots and small circles.

It will be noted in figure 2 that both lines have a sigmoid function. However, it is believed that the sharp drop at the upper extreme of each does not show truly valid relationships, as the values for iodine-starch score 7 are based on data from only one sample. With these limitations, intensity of reaction to the iodine spot test reliably indicated starch concentration and intensity of powder-post beetle infestation in the freshly harvested wood of the group of bamboo species tested.

SUMMARY.—Carbohydrate analyses were made of freshly harvested samples of five species of bamboo wood that corresponded to eight arbitrary gradations in the intensity of reaction to the iodine spot test for starch. The results of these analyses were correlated with the spot test gradations and with the bamboo powder-post beetle infestation that was obtained simultaneously in like samples in a standardized cage test. Regression lines were drawn showing the interrelationship of iodine spot test reaction, starch concentration, and beetle attack. Severity of attack by the adults of this insect was governed by the amount of starch present at time of exposure. Within certain limits, intensity of reaction to the iodine spot test was a reliable indication of starch concentration, and, as such, determined the intensity of subsequent infestation.

LITERATURE CITED

Association of Official Agricultural Chemists. 1945. Official and tentative methods of analysis. Ed. 5.

Plank, H. K. 1950. Studies of factors influencing attack and control of the bamboo powder-post beetle. Puerto Rico (Mayaguez) Federal Expt. Sta. Bul. 48.

EXPERT COMMITTEE ON INSECTICIDES

The third session of the Expert Committee on Insecticides will be held in Savannah, Georgia at the Communicable Disease Center of the U. S. Public Health Service probably between July 30 and August 4, 1951. At this session the host will be Dr. Brock Chisholm, Director-General of the World Health Organization of the United Nations.

Changing Problems and Procedures in Grasshopper and Mormon Cricket Control

CLAUDE WAKELAND, *Bureau of Entomology and Plant Quarantine, Agr. Res. Adm., U.S.D.A.*

Grasshopper control procedures have undergone more evolution in a period of five years since the advent of chlorinated hydrocarbon insecticides than during the preceding sixty years. Analyses of control needs emanate from knowledge of where problems exist. Since knowledge is derived from surveys, it is fitting that we briefly consider their purpose and kind.

SURVEYS PROVIDE BASIC INFORMATION.—Grasshopper and Mormon cricket population surveys are made annually by cooperating State and Federal agencies. They determine in advance the general infestation picture to provide the basis for planning for control needs the following season. Devised to obtain knowledge of infestations expected in an area by a reasonable consumption of time and manpower, they are not detailed for a specific locality or farm. A detailed survey is in the province of research or of State entomologists and county agents who feel it advisable to "pin-point" infested farms for more specific advice to individual farmers.

The grasshopper adult survey is made when it is possible to readily observe and estimate the number of adults present. In areas where supervisors have been directing control, information for mapping infestations is derived in part from the supervisor's intimate knowledge of grasshopper dispersion.

The technique for making an egg survey is more difficult and time-consuming than that for an adult survey. Furthermore, in the more northerly states, an egg survey is limited to the brief period between oviposition and the always probable weather restriction. The purpose of the egg survey is to determine whether the infestation expected in the succeeding year is the same, greater, or less than was shown by the adult survey and whether a shifting of adults, after the adult survey, has changed the infestation picture. The egg survey is conducted annually in areas where the adult survey revealed an expected economic infestation.

Every year the expected infestation, as determined from the egg survey, is either greater or less in some areas than from the adult survey. A typical example is an occurrence in the Lubbock, Texas, area. A survey of adults in the fall of 1942 revealed only a light infestation. *Melanoplus mexicanus mexicanus* (Sauss.) had been in flight in the area comprised of southeastern Colorado, southwestern Kansas and western Oklahoma. Flight direction was generally to the southwest. From the deduction that flights of grasshoppers might be reaching Texas or New Mexico, supervisors found heavy egg deposition in the Lubbock area in Texas. With that knowledge, preparations were made for control in 1943 when farmers in sixteen counties applied more than 7000 tons of bait to save their crops. In that instance, no control had been required the year previous and, with only normal population increase, little control would have been necessary in 1943.

Cooperators can plan for control needs for the following season with assurance when guided by reasonably accurate knowledge derived from population surveys of grasshopper adults and eggs. However, the actual grasshopper population to be controlled is not known until after predators, parasites and weather have exerted their toll in the period from egg deposition in the fall through the first and second nymphal instar periods in the spring. The remaining grasshopper population to be dealt with is determined by observations on the abundance of nymphs just before control operations should begin. Such observations are made by supervisors and State cooperators and the information obtained made available to farmers through publicity avenues of the cooperators.

How control expectancy is influenced by factors not measurable at the time of survey is illustrated by an occurrence in 1944 in the Great Plains area from Kansas to North Dakota and parts of Montana. Early-season weather conditions, unfavorable for small nymphs of *Melanoplus mexicanus mexicanus* caused heavy mortality to that species and greatly reduced the amount of control planned for.

The need to control grasshoppers on range land has necessitated enlarging the

adult and egg surveys to include range land on which cooperative control is planned for the succeeding year. Additional scouting is done to delimit the areas for range land control. Follow-up scouting work also is conducted to determine the thoroughness of control coverage, the effectiveness of results and whether changes in dosages and procedures should be made.

Survey for Mormon crickets is much less detailed than for grasshoppers. Information needed for planning control is obtained by mapping areas known to harbor populations of adults in the fall. An egg survey is not essential to control planning, for the reason that practicable and economical control is not undertaken in the spring until all eggs have hatched and the insects have begun to band and migrate. During this period, nymphs usually have moved away from egg bed locations, so areas to be baited must be determined by nymphal survey.

▶ NEW PROBLEMS INHERENT IN CHANGED CROPPING PRACTICES.—The grasshopper population usually changes when cropping practices are changed in an extensive area, so the resultant need for control is either increased or decreased. Numerous examples of such occurrences are available. A few will be cited.

Whole areas which had been producing cotton were planted to alfalfa during the period when the price of cotton was low and other economic factors unfavorable to cotton production in the Salt River Valley of Arizona. Grasshopper control on cotton had been mainly confined to marginal areas surrounding cotton fields which were plowed and cultivated annually. Alfalfa provided favorable field-wide breeding areas and abundant food for grasshoppers. In response to this different situation, control had to change from narrow strips of marginal vegetation to field-wide areas. Cotton was susceptible to severe grasshopper injury only when plants were young and tender, so control could be concentrated during that period. Numerous crops of alfalfa annually, however, furnished undisturbed soil for egg deposition and succulent plant food throughout the growing season, a combination very favorable to the survival and rapid increase of *Melanoplus differentialis* (Thos.) and especially of *M. mexicanus mexicanus* which in that area produces two or more generations annually.

In learning to live with grasshoppers in South Dakota, farmers have come to look upon corn as a chance crop that may be destroyed when grasshoppers, principally *Melanoplus differentialis*, invade corn fields from range or from grain fields when they are harvested. Sorghum is much less suceptible than corn to grasshopper attack, The agricultural experiment station has given much attention to breeding strains of sorghum of high feed value and the Extension Service has consistently promoted the planting of these improved strains. During years when it is known that grasshoppers will be abundant, spring planting has swung into a materially increased acreage of sorghum and a corresponding decrease of corn. Many farmers have learned that they can kill grasshoppers by spraying chlordane or toxaphene on vegetation on the margins of cornfields. Such a practice prevents invasion of corn and assures the production of a crop. As more farmers become aware of this they will have confidence to plant corn, thus the seasonal fluctuation between corn and sorghums may be expected to be partially or completely erased.

The recent under-supply and high price of alfalfa seed stimulated an increase in alfalfa acreage devoted to seed production and resulted in a greatly magnified problem of grasshopper control. Alfalfa cut for hay two or more times a year, and supporting a moderate population of grasshoppers, can be salvaged by cutting a crop before it is severely damaged and applying control measures to protect the next crop. Even with favorable moisture conditions, however, a moderate population of grasshoppers will completely ruin a seed crop.

A greatly expanded acreage has been planted to ladino clover for the production of seed and for irrigated pastures in the Sacramento Valley in California. This situation has provided an abundance of food and favorable breeding areas for grasshoppers and is increasing the control problem materially.

Low yields on worn-out or marginal lands and allotment restrictions caused replacement of cotton with pastures in vast areas in southern Texas. Pastures reached a new importance with the development of suitable pasture grasses

and of cattle breeds adapted to the climate. Prior to this year, reduced cotton acreage allotments encouraged the planting of only the better lands and further increasing yields by better insect control and by the use of fertilizers. Several spray applications per season for the control of cotton insects has so reduced grasshopper populations in the better producing areas that specific controls for grasshoppers are of much less importance. Grasshopper control in pasture areas now is simple compared to what it was when fields were in cotton with heavy growths of marginal weeds.

CHANGED SPECIES CAUSE CHANGED CONTROL PRACTICES.—The species which is predominant in a specific area governs the kind and amount of control required. Periodically, predominant species in nearly all areas are superseded by others. A few such instances are cited.

Melanoplus mexicanus mexicanus was the predominant species in crops and idle lands in 1939 in all of the plains states as far south as the Texas panhandle. This situation necessitated control applied on a field-wide basis. Since 1941 *M. mexicanus mexicanus*, although still as widely distributed, has largely been superseded in crops and idle lands by *M. bivittatus* (Say) and *M. differentialis*. Field-wide control of these species is largely avoided when timely control is accomplished in marginal areas. During this period *M. femur-rubrum* (Deg.) has increased in importance in alfalfa. It appears that *M. mexicanus mexicanus* increases during dry years and is replaced as the dominant species by *M. bivittatus*, *M. differentialis*, and *M. femur-rubrum* during long periods of normal or slightly subnormal rainfall. Excessive precipitation and sub-normal temperatures are detrimental to all economic species.

Melanoplus mexicanus mexicanus and *Aulocara ellitotti* (Thos.) species readily controlled by bait, were predominant in 1942 in certain range areas in eastern Arizona. In the same area in 1950, *M. mexicanus mexicanus* was conspicuous by its absence and *Boopedon nubilum* (Say), a species that eats bait sparingly, was predominant in large areas necessitating the use of spray to establish control.

Experience has shown that, besides natural factors, a succession in the predominance of species can be man-induced. Airplane baiting on range land in Montana and Wyoming in 1949 and 1950 reduced bait-controllable species of grasshoppers to non-economic importance where extensive areas were uniformly baited. However, the population composite included several species that fed little if at all on bait on the ground. The predominant species in several areas now is one that comprised only a minor percentage of the population composite before large-scale range control was undertaken. Many species which reluctantly eat bait are known to be included in the range land population composite. Some of the most important of these are:

Species that feed little if at all on bait:
Cordillacris occipitalis occipitalis (Thomas)
Phlibostroma quadrimaculatum (Thomas)
Metator pardalinus, Saussure
Opeia obscura (Thomas)
Amphitornus coloradus (Thomas)
Phoetaliotes nebrascensis (Thomas)
Trachyrachis kiowa kiowa (Thomas)
Melanoplus dawsoni (Scudder)
Species that reluctantly feed on bait:
Arphia pseudonietanna (Thomas)
Drepanopterna femoratum (Scudder)
Boopedon nubilum (Say)

NEW INSECTICIDES.—Practical grasshopper control can be roughly divided into three periods: Before Bait, Bait, and After Bait. Little organized control was possible until after 1885 when wet bran bait was first used in the United States. Grasshoppers were controlled almost exclusively by the use of wet bait from then until 1946, during which period the formula underwent many changes to improve the bait and lower its cost.

Used widely but not extensively in 1947, benzene hexachloride, chlordane, and toxaphene were applied as sprays or dusts with generally satisfactory results. Accompanying the availability of more abundant supplies of these new chemicals, the acreage sprayed and dusted with them expanded greatly with each succeeding year.

Sodium fluosilicate replaced arsenic in bait, and it in turn is being superseded partially by newer insecticides. The period "After Bait" probably will never become a complete reality, because under certain conditions bait of some form will continue to be more practicable than sprays and dusts.

Recently developed organic chemicals are rapidly being added to the impressive

list of grasshopper control insecticides, and the practicability of their use is increasing each year with the continued downward trend in the amount needed and the cost per acre. Chemists and manufacturers are developing new compounds faster than research can determine their effectiveness or limitations. Per-acre effective dosages of some of these new products are so minute that they are a never-ceasing source of wonderment to entomologists schooled to expect control in terms of pounds of insecticides per acre.

Representative of low-cost effective insecticides and possibly indicative of better things to come is aldrin which has been extensively tested by Canadian entomologists, by state agricultural experiment stations, and by the Bureau during the last 2 years. In 1950 it was applied to large range plots in Montana and Wyoming, used to control a grasshopper infestation on 42,000 acres of range in Arizona, and used almost exclusively by the Canadian Government to control a severe infestation of grasshoppers in Alberta, Manitoba, and Saskatchewan. Farmers also sprayed about 75,000 acres of crops with aldrin this year. Results in the United States have been almost uniformly satisfactory. When sprayed on vegetation harboring grasshoppers, two ounces of aldrin per acre in one gallon of kerosene or stove oil, or emulsified and added to water, has consistently resulted in economic control of all species, usually with one application. The effectiveness of sprays is proportionally reduced as elevations of single-engine aircraft increase above about 20 feet from the ground. Higher flying may prove effective when multiple-engine aircraft are employed and modifications made in aldrin spray formulations.

IMPROVED EQUIPMENT.—Treating extensive areas economically with wet bait stimulated the development of power equipment for uniformly mixing the ingredients and spreading the bait. A crew of six or eight men could inadequately hand-mix only a few tons of wet bait in a day. With power mixers now available the same sized crew in the same period can thoroughly prepare 144 tons of mixed bait. Two men spreading wet bait by hand could cover about six acres in a day, whereas with the best power ground-spreaders they cover about twenty times that acreage. A small airplane, such as a Stearman, properly equipped, and using dry bait, spreads bait on approximately 10 times the acreage a day as the best power ground-spreader. A large airplane such as a C-47 does the work of 10 small planes. With each step from hand-mixing and spreading to power mixing and airplane spreading, manpower is reduced with corresponding economy and increased speed.

Wet bait is difficult to dispense from an airplane and its moisture content reduces the per-acre capacity of a plane. Bran lightly impregnated with an oil solution of chlordane, toxaphene, or aldrin produces a bait which is readily and uniformly discharged from an airplane. Since the plane carries no useless weight of water, it will dispense dry bait on approximately twice the acreage it would if carrying wet bait.

The modification and use of two-engine aircraft evolved from the necessity for employing airplanes of large capacity for rapidly spreading bait on extensive range areas. Several C-47 airplanes were used on range operations in 1949 and 1950. These baited an average of more than 9000 acres each per day. Control of grasshoppers on extensive areas of low-priced range was not feasible until after the development of impregnated bran bait and suitable airplane equipment for handling it.

RANGE GRASSHOPPER PROBLEM.—Grasshopper control was for the protection of planted crops when organized control became a reality through federal legislation. Little attention was then given to range infestations. But in the late 1930's, many cooperators were becoming cognizant of the fact that migrations from range were an important and often the principal source of infestations attacking crops.

Public interest generally was not focused upon control of grasshoppers on range until late in the last decade. Ranchers had consistently absorbed or overlooked their losses in reduced forage and resultant reduction of range-carrying capacity. With build-ups of range populations and high prices for cattle, ranchers became increasingly insistent on the control of grasshoppers on range.

Undoubtedly a range grasshopper control problem has long existed in several

western states. Its importance was not stressed except by a few individual ranchers and by research agencies which were making range surveys and studies directed toward determining damage and population trends in suspected endemic centers.

The range grasshopper *Dissosteira longipennis* (Thos.) devastated thousands of acres of range and crop land in Colorado, New Mexico, and Texas in the late 1930's. Cooperative control of the species. was begun in 1938 and completed in 1941. Yearly surveys since then have revealed only single specimens of the species. Similar surveys in the future will reveal incipient infestations when they begin to build up. Incipient infestations can easily be stamped out and thus another outbreak can be averted at low cost.

Small areas of range in Wyoming were observed to carry heavier infestations and to show severe grass injury in 1946. In 1947, these areas had noticeably increased in size and numbers of grasshoppers, and ranchers successfully baited limited areas. Infestations increased and areas coalesced until by 1949 many thousands of acres were severely injured and several thousand acres were baited by ranchers. This rapid increase and spread gave rise to the state-federal control program in 1949 and 1950 under which more than five and a quarter million acres were baited in Montana and Wyoming.

It is reasonable to assume that had public funds, both state and federal, been available for controlling infestations in restricted areas when they were discovered in 1946 they could have been reduced to non-economic importance at a fraction of the expenditure for the 1949–50 control programs. Furthermore, the full grass production would have been available to grazing animals so the selling of livestock not in prime condition, the disposal of breeding herds and the dislocation of livestock industry which took place in some areas would not have been forced upon the ranchers.

The total per-acre cost of purchasing, transporting, and spreading bait on range areas in Wyoming and Montana was 67 cents in 1949 and the average cost of airplane hire was 26 cents. In Wyoming, in 1950, the total cost was 58 cents and the average airplane contract price was 18 cents per acre. Contractors this year were required to load their planes, whereas in 1949 loading was the responsibility of the state or federal cooperators.

Spraying range lands with an effective dosage of aldrin in solution with oil should not exceed the cost of baiting, providing the present price of the material and the cost of other contributing factors remain the same.

DEVELOPMENT OF OUTBREAKS.—Development of insecticide and equipment know-how has outdistanced development of knowledge of when a grasshopper outbreak begins and of means for obtaining control of an outbreak at its inception. Most entomologists will agree that infestations should be controlled before they increase and spread to outbreak proportions. Control of incipient infestations can be accomplished at a fraction of the cost necessitated in controlling widespread outbreaks. At that time, however, farmers and ranchers have little interest in controlling infestations that may ruin their crops or range within a year or two. Public interest is low during periods of light grasshopper damage and does not become aroused until after an outbreak has developed. Public means for grasshopper control usually are in proportion to public interest.

Much more research is needed concerning the causes of grasshopper outbreaks and when to recognize and stamp out local infestations before they develop into outbreaks. With such information, means for stamping out a small fire before it becomes a conflagration must be available if outbreaks are to be prevented. It is practical to continue to control grasshoppers in outbreak stages to protect crops and industries dependent upon them until research information and means are available for doing a better and less costly job at the right time.

PRECAUTIONS GUIDE USE OF INSECTICIDES.—Exhaustive research by industry and by public agencies is being done to obtain the answer to the question, "How safe to use is a certain insecticide recommended for grasshopper control?" Such research must continue and be extended to include new chemicals as they are developed. Final answers are years in the offing. Grasshopper control must go on and, pending availability of final answers, must be guided by such precautions as are known.

Experience has shown that when the use of benzene hexachloride, chlordane, toxaphene, and aldrin has been guided by the precautions outlined by manufacturers and by state or federal entomologists, grasshopper control has been obtained without apparent injury to livestock or humans or serious loss of bees. From the standpoint of livestock losses and injury to humans, sodium arsenite, which was used in grasshopper bait for many years, was more dangerous than the chemicals which have superseded it. Illness of pilots and workers using aldrin spray this year, in all cases reported to us, has resulted from accident or inattention to precautions. A chemical should not be condemned because accidental illness resulted from its use, for illness or death might result from accidental exposure to any insecticide.

The use of chlorinated hydrocarbon insecticides should be guided by precautions outlined by entomologists, manufacturers, chemists, and food and drug arbiters until specific information is available concerning the danger from these chemicals when stored in the fat of meat animals and in the milk of dairy cows that have consumed sprayed hay.

Concern is aroused over the effect on parasites and predators of organic insecticides applied as sprays or dusts for grasshopper control. Specific answers await results of exhaustive research. Conclusions are dangerous in the absence of specific knowledge of such things as the timing of sprays in relation to the vulnerable point in the life cycle of the parasite or predator, the specificity of a certain chemical on a certain species, the relative abundance of hosts and their insect enemies, the species of grasshoppers present, the probability of reinvasion of treated areas by insects from outside.

Generalizing, destruction of grasshopper insect enemies in farm areas by spraying probably is inconsequential because parasitism or predatism is important only locally and sprayed areas comprise but a fraction of the crop area. A high percentage of parasitism or predatism rarely occurs year after year in a single locality, whether or not grasshopper control is practiced. Where insect populations are reduced by spraying, parasites or predators which escape the spray or which invade from unsprayed areas may still be capable of reducing completely the remaining population of grasshoppers.

Serious disturbance of the balance between the host and its insect enemies is more likely to occur when whole areas of range are sprayed. Insect enemies of grasshoppers in range areas have been observed more rarely than in crop areas. When they develop to a point where they significantly reduce the grasshoppers it is probable that by knowing their emergence and breeding periods, spray applications may be timed effectively for grasshopper control without materially reducing the populations of parasites or predators.

Parasites and predators doubtless have not been fully credited for their year-in and year-out destruction of grasshoppers and their influence in delaying outbreaks. However, they have not kept ahead of their hosts in major widespread outbreaks where if crops are to be saved grasshoppers must be controlled without thought of immediate consequences to their insect enemies.

MORMON CRICKET CONTROL.—Mormon crickets infested vast areas in eleven western and midwestern states in the late 1930's and early 1940's. Individual states and counties alone financed control until Federal funds for assisting states were made available through the Works Progress Administration and under the administration of the Bureau in 1937. Bureau funds for assisting states have been available each year since. Over 14,000,000 acres were known to be infested in the fall of 1937, and nearly 19,000,000 acres in the fall of 1938. The area decreased until 1949 when only 116,000 acres were known to be infested. Although natural factors are responsible for decreases in some areas, decreases in many of the most troublesome areas leading to the present low population must be credited to consistent year-after-year control work.

Control of Mormon crickets in the early 1930's was by means of hand dust guns and sodium arsenite dust. It was slow, laborious, dangerous, and very costly. Hand dusting was superseded by power dusting during the period 1937 to 1941, resulting in increased area treated, more effectiveness, less cost and decreased danger. All dusting work was accompanied by the use of trench barriers, metal barriers and traps, or oil-on-water barriers. The cost of barriers and their main-

tenance was great. Control switched rapidly from dust to sodium fluosilicate bait, beginning in 1942, and then to bran impregnated with oil and insecticide. Bait was so effective that it stopped migrating bands of Mormon crickets better than barriers, thus barriers were eliminated and economy of operations increased. Power ground baiters were used generally but in some areas it has been more practical and economical to spread bait by airplanes. Each step in the change from hand-dusting to airplane baiting has increased effectiveness, decreased manpower requirements, and reduced expense until the per-acre cost is about one-third of that in 1938 or before.

Prevention of outbreaks of Mormon crickets is possible and feasible at low cost. By directing control against small concentrations of Mormon crickets in known infested areas they are being and can continue to be so decimated that they have no opportunity to band, migrate and coalesce into the large bands which grow to outbreak proportions.

Mormon crickets were observed in increasing numbers in several states in 1950, and they showed a banding and migrating tendency that they have not exhibited in recent years. Their distribution range now is nearly identical with what it was in the early part of the last decade when control was undertaken as far east as central South Dakota. Next year will be a critical year in the history of Mormon cricket control. Unless the many small bands are controlled a major outbreak may be in the making.

CONCLUSIONS.—With technical assistance from entomologists, farmers can well afford to protect their crops from grasshopper damage under present economic conditions and at present prices of effective insecticides.

Control of grasshoppers and Mormon crickets on range lands may not be undertaken extensively without public assistance.

Outbreaks of Mormon crickets and of the range grasshopper *Dissosteira longipennis* can be prevented at reasonable cost if public means are available for discovering and stamping out small infestations. Outbreaks of some other species of grasshoppers could be prevented but at exhorbitant cost. It appears practical, therefore, to continue controlling most species with the best means and methods available.

Research must be continued and expanded to supply the information needed to guide employment of the most economical and practicable control measures.

Spray Tests on Citrus to Control Fruit Tree Leaf Roller[1]

E. LAURENCE ATKINS, JR.,[2] *University of California Citrus Experiment Station, Riverside*

Infestation of citrus trees by the fruit tree leaf roller, *Archips argyrospila* (Walker), was reported first by Woglum & Lewis in 1935. They stated that this insect, which was then known as *Cacoecia argyrospila* Walker, had been observed for several seasons to be fairly abundant on grapefruit and Valencia orange trees near Lindsay, Tulare County, California, and that the larvae rolled the leaves of terminal growth shoots. Injury at that time was of little consequence.

Subsequently, Lange (1936) reported that larvae of a tortricid, *Cacoecia argyrospila*, were received from Porterville, Tulare County, on April 12, 1936, and that these larvae were webbing and rolling the leaves of orange trees and feeding on the buds. The infestation was first noticed in 1932 on a ranch 4 miles east of Terra Bella, Tulare County, where only 10 or 12 orange trees were infested. In April, 1936, it was found on the same ranch and on an adjoining 40 acres of oranges. By 1936 the species had spread 1 mile east of the original infestation and covered approximately 100 acres.

Woglum & Lewis (1947) reported another epidemic in the Porterville, Grandview, Lindsay, and Strathmore localities of Tulare County, which was the result of a 3-year build-up starting in the spring of 1945. In 1947 about 600 acres, mostly navel oranges, were treated with a 2 per

[1] Paper No. 658, University of California Citrus Experiment Station, Riverside, California.

[2] Appreciation is expressed to the various pest-control operators who arranged for experimental groves and assisted in applications, to the growers who permitted the use of their groves for these experiments, to the County Agricultural Commissioner personnel who cooperated in making the survey, and to the companies who so generously supplied the necessary experimental materials.

cent DDT-85 per cent sulfur dust on navels, and a 5 per cent DDT-talc dust on Valencias, at the rate of 100 pounds per acre. Both dust treatments were very effective in control.

PRESENT STATUS ON CITRUS.—In 1949 a rather light infestation of the fruit tree leaf roller was observed on navel and Valencia oranges in the Upland-Ontario portion of San Bernardino County, approximating 1,000 acres. In late April, 1950, attention was directed to an infestation in the adjacent Pomona section of Los Angeles County. Subsequent surveys showed that 2,700 to 3,000 acres were infested in eastern Los Angeles and western San Bernardino counties. About 450 acres of this epidemic were considered heavily infested and apparently warranted control. Lemons were also found to be lightly infested in these localities.

INJURY.—The initial injury consisted of rolling, webbing, and feeding on the shoots of the spring flush of growth. As soon as the new growth matured, the larvae abandoned it for the more tender blossoms and newly set fruit. They seldom fed on the older foliage.

Considerable damage was done to the blossoms in some groves, and after petal fall it was observed that the larvae had destroyed much of the newly set fruit. In two groves considerable damage was done to mature navel oranges on the trees, and a high percentage of oranges from one moderately infested navel grove was damaged while in a packing house where the fruit was stored for 3 days prior to washing and grading.

OBSERVATIONS ON THE LIFE CYCLE OF *Archips argyrospila* (WALKER).—The fruit tree leaf roller passes the winter in the egg stage. On citrus trees as on deciduous fruit trees, there is only one generation a year, the eggs being laid in the late spring and remaining unhatched until the following spring.

Observations in 1950 indicated that the first eggs began hatching approximately the middle of March and continued into the latter half of April. Shortly after the buds of the spring flush of growth began to open, the tiny larvae could be found feeding upon them. Hatching extended over a period of 3 weeks or more, and an average of about 4 or 5 weeks was required for a larva to become fully grown. On April 24 most of the larvae were in the second or a later instar, and by May 12 more than half of them were fully grown. As soon as the larvae were fully grown, they became quiescent and transformed to the pupal stage within a rolled-up leaf or cluster of leaves or mass of floral parts. Ten to 11 days were spent in the pupal stage, and at the end of this period transformation to the adult or moth took place.

The adults were first seen in citrus groves on May 11, and fresh egg masses were first found on May 15. Observations therefore indicated that mating and egg deposition took place immediately after transformation to the adult stage. The largest numbers of adults were observed in the groves around June 15. Few moths were noted after July 10, and the last adult was seen July 28 in this area.

Egg-mass deposition began in May, with the peak during the month of June. The egg masses may be found almost anywhere on the bark of citrus trees, but they are most numerous on twigs 0.25 to 1.5 inches in diameter and are concentrated in the upper third of the trees.

FIELD CONTROL EXPERIMENTS.—As previously mentioned, results with DDT applied as a dust had proved satisfactory, but no information was available concerning the use of sprays for the control of the larvae of this insect on citrus. Sprays were desirable because spray applications are made in many groves at the same time of year to control other pests. Immediate control was desirable because considerable injury had already occurred. Field experiments with various spray materials and application equipment were therefore undertaken.

The efficacy of the treatments was determined by observing 100 larval sites in each plot and recording the number of living larvae present before treatment and at appropriate intervals after treatment. The difference between the pre-treatment count and each subsequent post-treatment count provided a measure of effectiveness which is recorded in the tables as "index of mortality (expressed in per cent)." This method of evaluating a treatment was not entirely satisfactory. Although it provided a quick method of observing effectiveness, it did not indicate in what manner this was brought about. Some of the insecticides produced an irritation which caused the larvae to become dislodged from the tree and drop to the

Table 1.—Results of commercial field trials using DDT and cryolite applied with various types of mechanized application equipment for control of the fruit tree leaf roller on citrus, 1950.

Material	Pounds per Acre	Gallons of Spray[1] per Acre	Application Equipment[2]	Index of Mortality (Per Cent)[3] After— Days 1	2	4	6
DDT WP-50	4	500	SS	—	—	12	100
DDT WP-50	4	500	SS	—	—	21	95
DDT WP-50	4	500	SS	—	—	23	96
DDT WP-50	12	500	SS	51	—	—	99
DDT WP-50	8	500	SS	41	—	—	100
DDT WP-50	6	300	SD	—	91	—	95
DDT WP-50	6	300	SD	—	95	—	96
DDT WP-50	6	300	SD	—	97	—	95
DDT WP-50	5	150	SD	—	—	—	95
DDT WP-50	5	150	SD	—	—	—	97
DDT WP-50	5	300	SD	—	—	—	95
Cryolite (undiluted)	12	500	HBS	—	—	—	0[4]

[1] For applications at 300 gallons per acre, the spray-duster was operated at 150 pounds pressure at the nozzles; at 150 gallons per acre, 450 pounds pressure was used.
[2] SS = speed sprayer, SD = spray-duster, HBS = Hale boom sprayer.
[3] Difference between pre-treatment and post-treatment counts.
[4] After 14 days.

ground. Observations concerning this phenomenon were recorded, and variations in effectiveness of different dosages of an insecticide were largely explained by variations in this respect.

Results obtained in 12 groves treated commercially with DDT and cryolite sprays, with various types of mechanized application equipment, are given in table 1. These applications began at a time when most of the larvae were half grown. Since recommendations for dosages were not available, the amount of insecticide used was changed as information was obtained regarding efficacy of the treatment for practical control.

In this series of spray treatments (Table 1) DDT, at 4 pounds of a 50 per cent wettable powder per acre, was very slow in killing the larvae, although satisfactory control was effected after 6 days. Dosages of 12 and 8 pounds of DDT proved to be excessive. Treatments were subsequently lowered to 6 pounds, and finally to 5 pounds, of DDT 50 per cent wettable powder per acre. Cryolite was not effective when used at a dosage of 12 pounds of

Table 2.—Results of field trials using various materials applied with a conventional spray rig at the rate of 12 gallons per tree for control of the fruit tree leaf roller on citrus, 1950.

Insecticide (Wettable Powder)[1]	Pounds Per 100 Gal.	Pounds Per Acre	Index of Mortality (Expressed in Per Cent)[2] After— 1 Day	6 Days
Parathion, 25%	0.5	5	86	100
Parathion, 25%	1	10	52	100
Parathion, 25%	2	20	87	100
EPN-300, 27%	0.5	5	18	100
EPN-300, 27%	1	10	31	98
DDT, 50%	2	20	76	100
TDE, 50%	2	20	29	100
Methoxychlor, 50%	2	20	18	100
Ryania, 100%	6	60	—	69

[1] Shell Summer Spreader oil (1 qt./100 gal.) was added to each of these sprays. This spray adjuvant was supplied by the Shell Chemical Co., San Francisco, California.
[2] Difference between pre-treatment and post-treatment counts.

Table 3.—Results of field trials using various materials applied with a boom spray rig at the rate of 500 gallons per acre for control of the fruit tree leaf roller on citrus, 1950.

Insecticide (Wettable Powder)	Pounds per Acre	Index of Mortality (Expressed in Per Cent)[1] After— 2 Days	7 Days
DDT, 50%[2]	6	61	99
TDE, 50%	12	78	100
TDE, 50%	8	69	100
TDE, 50%[2]	6	62	100
Methoxychlor, 50%	12	51	66
Methoxychlor, 50%	8	33	83
Parathion, 25%	6	78	100
Parathion, 25%	3	80	100
EPN-300, 27%	6	62	99
EPN-300, 27%	3	46	100
Ryania, 100%[3]	30	33[3]	27

[1] Difference between pre-treatment and post-treatment counts.
[2] Shell Summer Spreader oil (1 pt./100 gal.) was added to this spray. This spray adjuvant was supplied by the Shell Chemical Co., San Francisco, California.
[3] In addition, 48 per cent of the insects in this plot were in a state of torpidity.

Table 4.—Results of field trials using various materials applied with a speed sprayer at the rate of 500 gallons per acre, for control of the fruit tree leaf roller on citrus, 1950.

Insecticide (Wettable Powder)[1]	Pounds per Acre	Index of Mortality (Expressed in Per Cent)[2] After— 2 Days	7 Days
DDT, 50%	8	88	100
DDT, 50%	6	97	98
TDE, 50%	8	92	99
TDE, 50%	6	91	100
Methoxychlor, 50%	8	74	96
Methoxychlor, 50%	6	79	96
Parathion, 25%	4	96	99
Parathion, 25%	3	100	100
EPN-300, 27%	4	90	100
EPN-300, 27%	3	89	100
Dieldrin, 25%	3	66	100
Aldrin, 25%[3]	6	56	89
Ryania, 100%	15	35	29

[1] Wettable sulfur was added to each of these sprays at the rate of 40 pounds per acre, with the exception of the aldrin plot.
[2] Difference between pre-treatment and post-treatment counts.
[3] Applied with spray-duster at the rate of 300 gallons per acre.

Table 5.—Results of field trials using aldrin, dieldrin, and TDE applied with a spray-duster at the rate of 300 gallons per acre for control of the fruit tree leaf roller on citrus, 1950.

Insecticide	Pounds per Acre of Actual Material	Index of Mortality (Expressed in Per Cent)[1] After—	
		3 Days	7 Days
Dieldrin, 12.5% emulsion	0.75	86	97
Dieldrin, 12.5% emulsion	0.75	62	84
Dieldrin, 25% wettable powder	0.75	55	86
Aldrin, 25% emulsion	1.50	59	78
Aldrin, 25% emulsion	1.50	64	73
Aldrin, 25% emulsion	0.75	84	88
Aldrin, 25% wettable powder	1.50	73	81
TDE, 50% wettable powder	3	95	99

[1] Difference between pre-treatment and post-treatment counts.

the undiluted material per acre.

The efficacy of control obtained in field trials when the insecticide was applied at the rate of 150 gallons per acre, using a spray-duster with a nozzle pressure of 450 pounds, was equivalent to that obtained when the insecticide was applied at the rate of 300 gallons per acre, using a spray-duster with a nozzle pressure of 150 pounds. Increased nozzle pressure apparently affords superior distribution of the spray mixture.

During the same period in which the commercial treatments were being applied in citrus groves, some of the newer insecticides were tested in experimental field plots. The materials used included the following: parathion,[3] ethyl *para*-nitrophenyl thiobenzenephosphonate,[4] DDT,[5] TDE,[6] methoxychlor,[7] *Ryania*,[8] dieldrin,[9] and aldrin.[9] These materials were applied with a conventional spray rig and several types of mechanized application equipment. Results are reported in tables 2 to 5.

Results of field trials with various materials applied with a conventional spray rig at a rate of approximately 12 gallons per tree are presented in table 2. With the exception of *Ryania*, which gave an index of mortality of 69 per cent, all of the materials were highly effective at the concentrations used. The data indicate that most of the materials were used at higher concentrations than necessary for control.

In the three plots where parathion was used, there were some variations in the 1-day index-of-mortality percentages. These may be partly explained by observations which showed very little irritation to the larvae at the dosage of 8 ounces per 100 gallons; therefore the number of larvae observed in the 100 sites was high. The 1-pound dosage increased the amount of irritation; many larvae became dislodged from the trees and dropped to the ground alive but subsequently died there. With the 2-pound dosage most of the larvae were apparently killed on the trees. These observations are supported by the index-of-mortality percentages for the 1-day counts.[4]

EPN-300 was slower than parathion in killing the larvae. This material caused the larvae to cease feeding, however, and by the end of the 6-day period a high degree of control had been effected.

In the DDT-treated plot, an index-of-mortality count indicated that 76 per cent of the larvae on the trees were dead after 1 day. Those remaining on the trees were moribund. Some larvae were on the ground; all of these were irritated and incapable of normal movements, and a few of them were dead.

One day after spraying, TDE and methoxychlor had not irritated the larvae as had DDT. In the TDE plot there were fewer larvae on the ground than in the DDT plot, and many of those remaining on the trees, especially the smaller ones, were not feeding. In the methoxychlor plot a few of the larvae that were not dead were somewhat affected, but only a small number were on the ground.

In the *Ryania*-treated plot, after 1 day, approximately 50 per cent of the larvae found on the trees were paralyzed and incapable of movement, but none were apparently dead. At the end of 6 days most of the larvae had recovered; only a few were killed by the treatment. In comparison with the other materials included in this series of tests, *Ryania* was somewhat low in effectiveness.

[3] Supplied by American Cyanamid Company, 30 Rockefeller Plaza, New York 20, N. Y.
[4] EPN-300. Supplied by E. I. du Pont de Nemours & Co. (Inc.), Grasselli Chemicals Department, Wilmington 98, Delaware.
[5] Supplied by several companies.
[6] Supplied by Rohm & Haas Co., Philadelphia 5, Pa.
[7] Supplied by E. I. du Pont de Nemours & Co. (Inc.), Grasselli Chemicals Department, Wilmington 98, Delaware.
[8] A botanical insecticide supplied by S. B. Penick & Company, New York, N. Y.
[9] Supplied by Julius Hyman & Company, Rocky Mountain Arsenal, Denver, Colorado.

In table 3 are presented the results of field trials with various materials applied with a boom sprayer (nozzles mounted on a vertical mast at appropriate intervals) at the rate of 500 gallons per acre. All these materials were highly effective at the concentrations used, with the exception of methoxychlor, which was somewhat less effective, and *Ryania*, which was only 27 per cent effective.

The two methoxychlor-treated plots showed some difference after 7 days. This might be explained by the difference in dosage, for many larvae were found dead on the ground under the trees given the 12-pound dosage, whereas only a few were dead on the ground under the trees given the 8-pound dosage. This does not explain results in the methoxychlor-treated plot of table 2, however, where, after a 20-pound dosage, only a few larvae were affected to the extent of dislodgment from the trees.

All tests with *Ryania* exhibited an unusual effect on most of the larvae 12 to 48 hours after treatment, namely, a state of motor inactivity, with partial or total insensibility to stimuli. In the trial reported in table 3, 48 per cent of the larvae that were not dead on the trees 2 days after treatment were paralyzed. Most of them had recovered after 3 days, however, and only a few died.

In table 4 are presented the results obtained in field trials with various materials applied with a speed sprayer at the rate of 500 gallons per acre. At the concentrations used these materials were very effective 7 days after treatment, with the exception of aldrin, which was somewhat less effective, and *Ryania*, which was only 29 per cent effective.

DDT, methoxychlor, and parathion at the higher dosages all exhibited variations after 2 days, caused, apparently, by differences in irritation to the larvae and subsequent dislodgment from the trees. In every instance in which the insecticide was effective, the lower dosage apparently would have afforded sufficient control.

In table 5 are presented the results obtained from field trials in which the effects of aldrin and dieldrin emulsions and wettable powders applied with a spray-duster at the rate of 300 gallons per acre were compared with those of TDE wettable powder as the standard. Aldrin and dieldrin were very promising in these trials, and there was little apparent difference between the emulsions and the wettable powders. Both aldrin and dieldrin were less effective than TDE, however, at the dosages used. Variation was high in most instances where the same insecticide-dosage combination was used, probably because of variation in the extent of pupation occurring. At the time this grove was treated, approximately 25 per cent of the larvae had already transformed to pupae.

SUMMARY.—The fruit tree leaf roller, *Archips argyrospila* (Walker), infested more than 2,700 acres of navel and Valencia oranges in western San Bernardino and eastern Los Angeles counties during April and May, 1950. Injury consisted primarily of rolling, webbing, and feeding on the shoots of the spring flush of growth. Extensive damage was caused by the larvae feeding on the blossoms, however, and after petal fall, it was observed that the newly set fruit had been eaten into and destroyed in many groves. In two groves considerable damage was done to mature navel oranges on the trees, and a high percentage of navel oranges from one moderately infested grove was damaged in the packing house where the fruit had been stored for 3 days prior to washing and grading.

Limited observations concerning the egg, larval, pupal, and adult stages of this insect on citrus trees are reported.

DDT used commercially at 6 pounds of a 50 per cent wettable powder in 300 to 500 gallons of water per acre, applied as a spray by speed-sprayer, boom-sprayer, or spray-duster equipment, gave satisfactory control of the larvae. DDT used commercially at 5 pounds also gave satisfactory control when applied with a spray-duster at the rate of 150 gallons per acre and operating with 450 pounds pressure at the nozzles. TDE, parathion, and ethyl *para*-nitrophenyl thionobenzenephosphonate also gave satisfactory control; methoxychlor, aldrin, and dieldrin were less satisfactory; and *Ryania* was only slightly effective at the concentrations used in these experimental trials. Of the mechanized spray-application equipment employed, the speed sprayer afforded the most uniform tree coverage, followed closely by the boom sprayer and the spray-duster.

LITERATURE CITED

Lange, W. Harry, Jr. 1936. The fruit leaf roller *Cacoecia argyrospila* (Wlk.) a defoliator of the orange in California. Calif. Dept. Agr. Bul. **25**(3): 387.

Weldon, Geo. P. 1913. The fruit-tree leaf-roller (*Archips argyrospila* Walker). Calif. State Com. Hort. Monthly Bul. **2**(9): 637–47.

Woglum, R. S., and H. C. Lewis. 1935. Notes on citrus pests new or seldom injurious in California. JOUR. ECON. ENT. **28**(6): 1018–21. (See especially p. 1021.)

Woglum, R. S., and H. C. Lewis. 1947. Leaf roller attacks citrus trees. Calif. Citrog. **32**(7): 308–9.

Control of *Hylemya brassicae* in Radishes[1]

LOYD L. STITT,[2] *Puyallup, Washington*

The cabbage maggot *Hylemya brassicae* Bouché causes extensive damage to radishes in western Washington. Infestation varies from less than 10 per cent to over 80 per cent of the radishes. Calomel treatment, the standard control, is costly and often ineffective, but some of the new insecticides used in the investigations consistently gave effective control.

Many of the advances and changes made in the cabbage maggot control during the last 35 years are reviewed by Carlson, *et al.* (1947) and Crowell, *et al.* (1948). Radishes were used to test the effectiveness of many new insecticides at different concentrations in maggot control in Pennsylvania (Dills & Odland 1948). Chlordane and benzene hexachloride were the most effective. Benzene hexachloride at rather high dosages (Crowell, *et al.* 1948) resulted in practically 100 per cent control of the maggot in radishes, rutabaga, broccoli, mustard and kohlrabi. Excellent control resulted when different methods of treating the plants with chlordane were used in Washington (Eide & Stitt 1950).

Radishes were used in this investigation to evaluate additional new insecticides and to find a practical control of the cabbage maggot in radishes by using but one application at relatively low dosages.

METHODS AND MATERIALS.—In 1949, insecticides were broadcast over the soil surface, banded in approximately 2-inch wide strips centered over the row, and placed in the furrow with the seed. In the 1950 investigations, all insecticides were applied in the furrow. The Comet radish was used in all tests. These tests were arranged in the randomized block design on Sultan silt loam at Puyallup.

The Broadcast Applications.—Weighed amounts of the insecticides were distributed as uniformly as possible over the 10 by 22.5-foot plots on June 24 and incorporated into the upper one-eighth to one-quarter-inch of soil by raking. Radish seed was planted the day following the insecticide application. The insecticides, concentration of dusts, and dosages used are presented in table 1. All radishes were examined for maggot infestation on July 29. The radishes were more mature than used for marketing, but the additional growth period allowed for maximum maggot infestation. In table 1 data on number of radishes examined, mean infestation for the different treatments, and significance required are recorded.

Furrow and Band Application.—The furrow and band application was made by applying, with a salt shaker, 1.5 teaspoonsful of the insecticide per 5 feet of row. The furrow was made and seed placed. Then the insecticide was shaken on the seed in the furrow for the "furrow method" of application. The "band method" consisted of shaking the dust on the soil surface on the mark left by the seeder indicating the seeded area. Radishes were planted August 5 in the band application plots and insecticide applied on August 8. In the furrow application the radishes were planted August 8, the same date as insecticide treatment. Infestation records were secured by examining all radishes in each plot for both the furrow and band application methods on September 20 and 21. Mean infestation is given for each treatment, as is difference required for significance at the 5 and 1 per cent levels.

Furrow Application—1950.—The radish seed was planted with a *Planet Jr.* planter in row plots 10 feet long. Insecti-

[1] Scientific Paper No. 983, Washington Agricultural Experiment Stations, The State College of Washington, Pullman.

[2] Assistant Entomologist, Western Washington Experiment Station, Puyallup.

cides were applied at the rate of 1 tablespoonful per plot, the radish seed being placed with the insecticide in the furrow. Plantings were made on May 1, 9, 19, and 26, and June 9. Infestation data were taken when the radishes were at the marketing stage of maturity, approximately 30 days after planting. Fifty radishes were selected at random from each plot and examined for maggot injury. The kind of insecticide used, concentration, amount per acre, planting date of radishes, and mean infestation of the maggot are tabulated in table 2.

DISCUSSION.—The amount of actual insecticide used per acre was from 2.5 to over 6 times as great in the broadcast application as in the band or furrow application. The band and furrow application concentrates the insecticide near the radishes, where control is essential. Broadcast and band application of lindane did not give satisfactory maggot control, but furrow application gave excellent control.

Off-flavor was detected in the 1950 lindane treatment. This off-flavor was more noticeable in the late May and early June plantings than in the early May plantings. Radishes in the other plots were checked for off-flavor when the maggot infestation data were taken. No off-flavor was noted in the parathion, chlordane, aldrin, or dieldrin treatments.

An abnormal growth of the radishes was observed, particularly in certain treatments. This consisted of an extra small radish growing on the root of the radish about one-eighth to one-half-inch from the base of the normal radish. Four to 8 per cent of the radishes with abnormal growth were observed in the lindane plots, whereas this growth condition was rarely found in the other treatments. The greatest number of abnormal radishes was found in the May 26 and June 6 plantings. The numbers of abnormal radishes in the various treatments for the May 26 and June 6 plantings were: aldrin, 1; chlordane, 2; dieldrin, 2; lindane, 31; parathion, 2; and untreated check, 1.

PHYTOTOXICITY.—The insecticides that gave excellent control in the field tests were selected for greenhouse investigations to determine if fairly high dosages

Table 1.—Effect of method of insecticide applications on cabbage maggot control in Comet radishes grown in Sultan loam. Puyallup, Washington—1949.

TREATMENT (DUSTS)	METHOD OF APPLICATION							
	Broadcast[1]			Furrow[2]			Band[2]	
	Amount[3] per Acre	Radishes Examined	Mean Infestation	Amount[3,4] per Acre 12″ Rows	Radishes Examined	Mean Infestation	Radishes Examined	Mean Infestation
	Pounds	*Numbers*	*Per Cent*	*Pounds*	*Numbers*	*Per Cent*	*Numbers*	*Per Cent*
Benzene hexachloride 1% gamma	2.5	284	41.7	—	—	—	—	—
Lindane 1%	2.5	264	51.1	0.9	715	1.9	422	12.7
Parathion 1%	5.0	291	18.8	1.0	679	2.4	461	5.9
Chlordane 5%	25.0	246	11.2	4.9	556	2.1	501	3.7
Aldrin 2.5%	12.5	271	12.3	2.0	697	0.8	412	3.6
Dieldrin 2.5%	12.5	261	3.7	2.1	693	0.5	422	1.0
Am. Cy. 3869 2.5%[5]	12.5	280	65.6	2.4	585	20.3	452	26.7
Am. Cy. 3901 2.5%[6]	12.5	289	55.5	2.4	786	14.9	560	22.1
H.M. 204[7]	—	—	—	17.2[8]	625	13.9	426	19.7
CS 645A 2.5%[9]	12.5	296	68.4	2.1	620	26.9	433	14.4
Untreated Check	—	288	68.7	—	651	16.2	393	21.1
Difference required for significance								
at 5% level			18.5			10.1		12.6
at 1% level			25.0			13.5		17.0

[1] 4 replicates.
[2] 6 replicates.
[3] All amounts are for actual toxicant.
[4] Amounts used for band were the same as furrow.
[5] S-mercapto acetyl urea 0,0-dimethyl dithiophosphate, American Cyanamid Co.
[6] 0,0-dimethyl S-(2-oxo-2-ureido ethyl) dithiophosphate, American Cyanamid Co.
[7] Basic copper arsenate 13.65%, Sulfur 46.5%, DDT 2.0%, Lester Hanna, Forest Grove, Oregon.
[8] Based on actual basic copper arsenate and DDT.
[9] 2-Nitro,-1,1,-bis(*p*-chlorophenyl)propane, Commercial Solvents Corporation.

Table 2.—Effect of different planting dates of Comet radish on cabbage maggot control. Puyallup, Washington—1950.

Treatment (Dusts)	Planting Dates							
	May 1			May 9		May 19	May 26	June 9
	Amount[1] per Acre	Mean[2] Infestation	Amount[3] per Acre	Radishes[2] Examined	Mean Infestation	Mean Infestation	Mean Infestation	Mean Infestation
	Pounds	*Per Cent*	*Pounds*	*Numbers*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
Parathion 1.0%	0.4	3.3	1.0	141	1.5	0.7	0.3	0.0
Lindane 1.0%	0.9	0.0	0.9	140	0.0	1.0	1.0	0.0
Chlordane 5.0%	5.7	2.7	4.9	134	0.0	0.0	0.0	0.0
Aldrin 2.5%	2.4	4.0	2.0	150	5.3	0.3	0.0	0.0
Dieldrin 2.5%	5.2	2.7	2.1	143	2.7	0.0	0.0	0.0
Untreated Check	—	35.3	—	133	56.8	39.3	43.7	12.7
Difference required for significance								
at 5% level		6.5			10.4	7.4	8.9	4.6
at 1% level		8.7			14.8	10.1	12.0	6.2

[1] Actual toxicant with rows 18 inches apart.
[2] 300 radishes examined for each treatment except for the May 9 planting.
[3] Actual toxicant with rows 12 inches apart. Amounts used were the same for the plantings on May 9, 19, and 26, and June 9.

caused plant injury. Seed of the Comet radish was used. Aldrin, 2.5 per cent; dieldrin, 2.5 per cent; chlordane, 5 per cent; parathion, 1 per cent; and lindane, 1 per cent were used. These insecticides were added to a small furrow at rates of one-half and 1 teaspoonful per 19 inches. The radish seed was then placed in the furrow with the insecticide and covered with soil. Readings on emergence, plant height, and color appearances were taken. Plantings were made on April 1, 7, 10, 13, 17, and 27. Stunting was observed in one case of the six when one-half teaspoonful of chlordane was used. This amount is approximately the same as 1 tablespoonful per 10-foot row in the field. No stunting was observed in the field. At one teaspoonful per 19 inches—twice the field application—stunting was observed once in lindane, once in benzene hexachloride, and twice in chlordane in the six plantings.

SUMMARY.—Insecticides were applied by broadcasting, banding, and furrowing for the control of the cabbage maggot in radishes. Nine insecticides were compared with the untreated check. Aldrin, 2.5 per cent; chlordane, 5 per cent; dieldrin, 2.5 per cent: and parathion, 1 per cent, applied in the above three methods, resulted in a highly significant reduction of the cabbage maggot when compared with the untreated check. In the furrow application, lindane was effective at the 1 per cent level. Off-flavor was detected in the lindane treatment. Furrow and band application required from one-third to one-sixth as much actual toxicant as the broadcast application. Some stunting of the radishes was observed in the greenhouse with treatments of lindane, benzene hexachloride, and chlordane.

The cabbage maggot investigations show that infestation in the untreated check varies at different dates. There was a high of 68.7 per cent infestation in July of 1949, compared with a low of 12.7 per cent in the June 9, 1950 planting. The mean infestations in percentage for the planting dates of 1950 were: May 1, 35.3; May 9, 56.8; May 19, 39.3; May 26, 43.7; and June 9, 12.7.

LITERATURE CITED

Carlson, Elmer C., E. P. Breakey and R. L. Webster. 1947. The cabbage maggot in Northwest Washington. JOUR. ECON. ENT. 40: 57–64.

Crowell, H. H., H. E. Morrison, S. E. Crumb, Jr., and W. R. Lauderdale. 1948. Cabbage maggot control by the use of benzene hexachloride in the soil. JOUR. ECON. ENT. 41: 362–5.

Dills, L. E., and M. L. Odland. 1948. Cabbage maggot insecticide tests. JOUR. ECON. ENT. 41: 98–101.

Eide, Paul M., and Loyd L. Stitt. 1950. Comparisons of insecticides for cabbage maggot control on cole crops. JOUR. ECON. ENT. 43(6): 899–905.

Chlorinated Chemical Control of the Sandhill Cutworm[1]

ROSCOE E. HILL and MARTIN H. MUMA, *University of Nebraska, Lincoln*

The sandhill cutworm, *Euxoa detersa* (Walker), frequently is a problem to corn growers who farm the lighter sandy soils in Nebraska. Heavy infestations and injury occur almost every year in 15 to 20 counties in the north central area of the state. Losses in many fields are so great that corn must be replanted two or three times before a stand is obtained. In the past the use of bran baits proved effective in the control of this cutworm, but, because of labor shortages in the area, the practice generally has been abandoned.

A field test of chlorinated chemicals was conducted in Pierce County during 1948 for the control of the banded webworm *Thaumatopsis pectinifer* (Zell.). An injurious webworm population failed to develop, but the striking differences obtained in corn stands indicated excellent control of the sandhill cutworm which was present in large numbers. As a local survey revealed moderate to heavy losses in most cornfields in the area, control studies on the cutworm were continued in 1949 and 1950. Results obtained during the three year study are presented here.

PROCEDURE AND METHODS.—The experiment conducted in 1948 consisted of five replications of four chemical treatments: DDT at 5 pounds, toxaphene and chlordane at 1 pound and benzene hexachloride at 1 pound of the gamma isomer per acre. All four chemicals were applied, before planting, to one set of plots and at the time of the first cultivation, to another. Untreated controls were established for both treatment dates. All chemicals were applied as sprays, DDT and benzene hexachloride as suspensions and chlordane and toxaphene as emulsions, at the rate of 100 gallons per acre. Pre-planting treatments were applied to the entire soil surface on May 4, whereas post-emergence treatments made at the time of the first cultivation (May 28) were directed at the bases of the plants. Individual plots were eight corn rows wide and 50 feet long. Effectiveness of the treatments was determined from stand counts taken in the middle four rows of each plot.

In 1949 no replicated tests were conducted. Observations and records, however, were taken on demonstration field strips treated with several dosages of DDT that varied from one-half to two pounds of toxicant per acre.

Timing of applications was investigated in two fields in 1950. DDT at 1 pound per acre and toxaphene at 2 pounds per acre were applied before planting on May 18, after planting on May 18 and 24, and at the time of first cultivation on June 3. The chemical treatments were applied as emulsion sprays at a rate of 12 gallons per acre over the entire soil surface. Untreated controls were included with each of the three sets of treatments. All treatments and controls were replicated four times in plots four corn rows wide and 30 feet long. Results were evaluated from post-treatment counts of surfaced, dead and dying cutworms and stand counts taken in the two center rows of each plot on June 3 and July 7.

RESULTS.—Data collected in 1948 are summarized in table 1. Although no counts of surfaced cutworms were made this season, sharp reductions in corn stand loss in some plots indicated effective control. All the materials applied as pre-planting treatments significantly protected the stand from May 4 to May 28. On August 3 stand counts showed the DDT pre-planting plots to be significantly better than all others, although the BHC and chlordane pre-planting treatments also remained significantly better than the untreated check plots. It is also evident from table 1 that the post-emergence treatments were applied too late to be practical; only DDT reduced the stand loss to an extent approaching significance.

Observations and records on the demonstration field established in 1949 indicated that DDT could be used at a rate of 1 pound per acre. This reduced dosage was utilized in the 1950 experiments.

The 1950 data are summarized in table 2. Only the DDT post-planting treatment was significantly better than the check on the basis of stand on June 3 or at the time post-emergence treatments were made. From June 3 to July 7 cutworms

[1] Published with the approval of the Director as Paper No. 519 Journal Series, Nebraska Agricultural Experiment Station.

Table 1.—Stand counts and percentage stand losses of corn treated with chlorinated insecticides, Pierce County, 1948.

Treatment Time and Dosage per Acre	Mean Stand Count per 50 Feet of Row		Stand Loss from May 28 to Aug. 3 Per Cent	Total Per Cent Loss from Est. Perfect Stand of 36 Plants
	May 28	Aug. 3		
Pre-planting (May 4)				
Gamma BHC 1 lb.	27	18	33.3	50.0
Chlordane 1 lb.	30	19	36.6	47.2
Toxaphene 1 lb.	24	12	50.0	66.7
DDT 5 lb.	33	30	9.1	16.7
Post-emergence (May 28)				
Gamma BHC 1 lb.	14	8	42.9	77.8
Chlordane 1 lb.	14	9	35.7	75.0
Toxaphene 1 lb.	19	13	31.6	63.9
DDT 5 lb.	18	15	16.6	58.3
Untreated Control	14	8	42.9	77.8
Difference Required for Significance at 19:1	8	8	26.6	23.0

Table 2.—Apparent kill of *Euxoa detersa* (Wlk.), stand counts and percentage stand losses of corn following timed treatments with DDT and toxaphene in Pierce County, Nebraska, 1950.

Treatment Time and Dosage per Acre	Per 60 Feet of Corn Row			Per Cent Loss on July 7 from Est. Perfect Stand
	Surfaced Cutworms 18–20 Hrs. After Treatment	Mean Stand		
		June 3	July 7	
Kroupa Field[1]				*34 Plants*
Pre-planting (May 18)				
DDT 1 lb.	1.7	28.5	21.7	36.2
Toxaphene 2 lb.	0.6	26.7	20.2	40.6
Post-planting (May 24)				
DDT 1 lb.	3.2	33.5	29.5	13.2
Toxaphene 2 lb.	1.1	26.5	23.2	31.8
Post-emergence (June 3)				
DDT 1 lb.	4.5	21.7	18.7	45.0
Toxaphene 2 lb.	0.0	23.0	19.7	42.0
Untreated Control	0.0	21.8	12.1	64.4
Difference Required for Significance at 19:1		7.2	10.1	29.9
Dean Field[2]				*35 Plants*
Pre-planting (May 18)				
DDT 1 lb.	0.7	31.2	28.2	19.4
Toxaphene 2 lb.	0.0	30.7	27.5	21.4
Post-planting (May 19)				
DDT 1 lb.	10.5	33.5	31.2	10.8
Toxaphene 2 lb.	2.5	32.5	28.5	18.6
Post-emergence (June 3)				
DDT 1 lb.	18.0	27.2	26.2	25.1
Toxaphene 2 lb.	2.2	26.7	27.2	22.3
Untreated Control	0.0	30.4	25.5	27.1
Difference Required for Significance at 19:1	8.3	[3]	[3]	[3]

[1] Corn planted May 20.
[2] Corn planted May 18.
[3] Data not statistically significant.

were still active, but stand losses were significantly reduced in both DDT and toxaphene post-planted treated plots. Therefore, the most efficient time for treatment seems to be immediately after planting. Pre-planting treatments which were listed under at the time of planting and post-emergence treatments applied after damage was noticed were less effective. DDT at 1 pound per acre was more effective than toxaphene at 2 pounds per acre. The data further indicate that a higher dosage of DDT applied ahead of planting might possibly have been effective, since the percentage stand loss for this treatment fell just short of significance.

DISCUSSION AND CONCLUSIONS.—An investigation of the control of cutworms is complicated by many factors. This should be readily apparent to anyone examining published literature on the subject. Generalizations regarding control of noctuids with organic chemicals are difficult to make because of differences in ecology, physiology and habits of the several species concerned. It is important that entomologists keep those facts in mind when recommending control measures or when investigating the control of any one species of cutworm. Chemicals found effective against a species in one locality are not necessarily the best materials to use against other species in another locality. The importance of these factors was evident in the present study.

The necessity of using small experimental plots is a source of error in the experiments reported here. In the case of the sandhill cutworm, migration and subsurface feeding habits cause gradual reductions of stand in treated plots adjoining untreated control plots. Furthermore, heavy populations of the species existed only in Valentine or blow sands with a sharp decrease in numbers occurring on loamy sands or sandy loams. For this reason margins of test plots designed to cover sandy knolls or ridges usually had much less injury than the centers causing wide inter-plot variation in cutworm and stand counts. Nevertheless, the results obtained were sufficiently good to justify a report at this time.

The following conclusions are indicated from the experimental data. DDT is more efficient in controlling the sandhill cutworm than toxaphene, chlordane or benzene hexachloride. Comparable results may be expected with emulsion or wettable powder sprays applied either at high or low gallonage per acre. Post-planting treatment with DDT is more effective than are treatments made before planting or after emergence of the corn.

A practical demonstration of the effectiveness of the use of DDT for this cutworm was observed in 1950 in several commercial fields. These observations lend support to the conclusions stated above. Fields sprayed with DDT at 1 pound per acre immediately after planting presented excellent stands, whereas nearby untreated fields were severely damaged. On one farm where fields had been under observation for four years, results were striking. For the first time during that period it was not necessary for the farmer to replant and the first time he had been able to maintain an almost perfect stand.

SUMMARY.—DDT is more effective than chlordane, toxaphene or gamma benzene hexachloride for the control of the sandhill cutworm, *Euxoa detersa* (Walker), in cornfields. As little as one pound of DDT per acre, applied as a spray, gives excellent control. Better stands are obtained when treatment is made to the surface of the soil immediately after planting.

Further Tests of Dibutyl Adipate as a Tick Repellent[1]

PHILIP GRANETT and CARL F. FRENCH,[2] *Rutgers University, New Brunswick, N. J.*

A previous paper, Granett & French (1949) reported that dibutyl adipate and n-hexyl mandelate applied to clothing provided excellent protection against the American dog tick *Dermacentor variabilis* Say. During the past season the tests with these materials were extended to determine whether the results obtained with them could be confirmed; whether aerosol application was practical; and whether dogs could be protected.

EMULSIONS APPLIED TO CLOTHING.—All the testing[3] was against *Dermacentor variabilis* Say in the vicinity of Amagansett, Long Island, N. Y., beginning June 5 and continuing for 7 weeks. The area selected[4] was a heavily infested network of paths extending for approximately 2 miles. As a result of preliminary observations which showed a population of at least 50 to 100 ticks in 100 yards, exposure during the tests was standardized to a slow walk of 30 minutes (or 1 mile) along the pathways. Ticks were allowed to crawl up to the knee or above and then were removed and counted. A person wearing untreated clothing to serve as a check always accompanied a tester, following approximately 50 yards behind the person wearing the treated apparel. All tests were replicated three times. Tests of each series of treatments were usually conducted at weekly intervals. The treated coveralls or trousers were loosely rolled and stored in paper bags between treatments.

The standard treatment for clothing was a water emulsion impregnation at 2 grams of chemical per square foot of cloth. Dilutions of 1 to 16 in water were made from concentrates of 90 parts chemical to 10 parts emulsifier. Approximately 1 qt. of emulsion was needed for coveralls and 1 pt. for trousers.

In the first series of tests (Table 1), Army HBT coveralls were impregnated with dibutyl adipate, n-hexyl mandelate, and indalone (n-butyl mesityl oxide oxalate). During the testing period the coveralls were washed twice, once 4 weeks after application of the chemicals and again after 5 weeks. Dibutyl adipate provided the most consistent protection. It was still very effective, 98 per cent repellency, at the end of the testing period despite the two washings. Hexyl mandelate, although not quite so effective, also provided good protection and also withstood two washings. Butyl mesityl oxide oxalate[5] was fairly effective until washed; then protection dropped from 81 per cent to 40 per cent.

In the second series of tests (Table 2) trousers were treated with dibutyl adipate, n-hexyl mandelate, isopropyl adipate, propyl adipate, n-butyl acetanilide

Paid paper.
[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Department of Entomology.
[2] Investigations conducted under a research fellowship sponsored by Carbide and Carbon Chemical Division, Union Carbide and Carbon Corporation at Rutgers University.
[3] In addition to the authors, test personnel included Kile Barbehenn and Ralph Martinson.
[4] Area selected through the cooperation of Dr. D. L. Collins and Mr. R. V. Nardy, of the New York State Science Service.
[5] *Indalone* (Test material 1, or TM-1).

Table 1.—Tick repellency tests using emulsion-treated coveralls.

COVERALLS TREATED 5/25/50[1]	AVERAGE OF 3 REPLICATE TESTS MADE AFTER									
	3 Weeks		4 Weeks			5 Weeks			7 Weeks	
	No. Ticks	% Rep.	No. Ticks	% Rep.		No. Ticks	% Rep.		No. Ticks	% Rep.
Dibutyl Adipate	2	98	2	98	WASHED	2	98	WASHED	2	98
n-Hexyl Mandelate	14	83	13	87		17	83		9	88
Butyl Mesityl Oxide Oxalate (Indalone)	12	85	19	81		60	40		47	39
Untreated	79	—	100	—		98	—		76	—

[1] 2 gr. chemical/sq. ft. cloth using a concentrate of 90 parts chemical to 10 parts *Goremul A* (Glycol Products Co.) diluted 1 to 16 parts of water.

Table 2.—Tick repellency tests using emulsion treated trousers.

Trousers Treated 5/25/50[1]	Average of 3 Replicate Tests Made After: 2 Weeks No. Ticks	2 Weeks % Rep.	3 Weeks No. Ticks	3 Weeks % Rep.
Dibutyl Adipate	3	99	2	98
n-Hexyl Mandelate	16	92	4	96
Butyl Mesityl Oxide Oxalate[1]	58	68		
Propyl Adipate	34	82		
Iso-Propyl Adipate	52	71		
n-Butyl Acetanilide	40	78		
Untreated	180	—	103	

[1] 2 gr. chemical/sq. ft. cloth using a concentrate of 90 parts chemical to 10 parts *Emulsifier A* (Glycol Products Co.) diluted 1 to 16 parts water.

and Butyl Mesityl Oxide Oxalate. N-Butyl acetanilide had been reported (Cole & Smith 1949) highly effective against the lone star tick, *Amblyomma americanum* L. but gave only 78 per cent protection against *Dermacentor variabilis*. Again dibutyl adipate and hexyl mandelate provided best protection. The remaining materials all gave protection of less than 90 per cent when tried two weeks after application to the trousers.

The third series of tests (Table 3) was designed to determine whether the emulsifier affected repellency. *Emulsifier A*,[1] used in the previous tests, is somewhat difficult to work with because with some materials heat or long agitation is required for solution. It was found that *Emulsifier B* could be used satisfactorily with dibutyl adipate or hexyl mandelate; *Emulsifier C* was also satisfactory with dibutyl adipate. There was no apparent difference in effectiveness due to emulsifier used.

AEROSOL TREATMENTS ON TROUSERS.—The use of aerosols for many purposes is now widespread; but it was not known whether such a form of application would be suitable for protection against ticks. Low pressure aerosols[2] containing 5 and 15 per cent of either dibutyl adipate or n-hexyl mandelate were prepared with a mixture of equal parts of *Freon 11* and *Freon 12*. They were applied to trousers to provide a treatment of 1 to 2 grams of active ingredient per square foot of clothing (Table 4). The protection obtained from such treatments was found to be as good as from emulsion treatment. Dibutyl adipate is again considered to be the preferred material, not only from the viewpoint of better protection but also because of its lack of irritation and odor in the mist form. It is estimated that 3 or 4 complete treatments of trousers could be obtained from one low pressure (1 lb.) aerosol bomb of the 15 per cent concentration; this concentration would probably be more economical to use than the 5 per cent concentration. Because this method of treatment is apparently effective, is rapid and easy to use, aerosol application of tick repellents is especially promising for those who have occasional need for protection from these pests.

EMULSIONS ON DOGS.—A beagle and two short-haired terriers were washed with the emulsions used for clothing and in quantities to provide an application of

[1] The three emulsifiers used were—
A—Goremul A; Glycol Products Co.,
B—Tween 80, Atlas Powder Co.,
C—Triton X-100, Rohm and Haas Corp.
[2] Prepared through courtesy of Dr. Harry L. Haynes.

Table 3.—Tick repellency tests using emulsion-treated trousers—comparison of emulsifiers.

Trousers Treated 6/20/50[1]	Emulsifier	Tests Made After: 1 Day No. Ticks	1 Day % Rep.	1 Week No. Ticks	1 Week % Rep.	3 Weeks No. Ticks	3 Weeks % Rep.
Dibutyl Adipate	*Emulsifier A*	1	99	0	100	0	100
Dibutyl Adipate	*Emulsifier C*	1	99	0	100	0	100
n-Hexyl Mandelate	*Emulsifier A*	15	90	6	93	4	95
n-Hexyl Mandelate	*Emulsifier B*	2	98	9	91	4	95
45% Hexyl Mandelate 45% Dibutyl Adipate	*Emulsifier B*	0	100	1	99	0	100
Untreated		154	—	104	—	83	—

[1] 2 gr. chemical/sq. ft. cloth using a concentrate of 90 parts chemical to 10 parts emulsifier diluted 1 to 16 parts water.

Table 4.—Tick repellency tests using aerosol-treated trousers.

TROUSERS TREATMENT AND DATE	PER CENT IN AEROSOL[1]	GRAMS CHEM. PER SQ. FT. CLOTH	Fresh		After 1 Day		After 1 Week		After 2 Weeks		After 3 Weeks	
			No. Ticks	% Rep.	No. Ticks	% Rep.	No. Ticks	% Rep.	No. Ticks	% Rep.	No. Ticks	% Rep.
Hexyl Mandelate (6/22/50)	5	1.6	0	100	3	98	4	96	—	—	0	100
Dibutyl Adipate (6/22/50)	5	1.6	0	100	0	100	2	98	—	—	0	100
Untreated			133	—	128	—	84	—	—	—	81	—
Hexyl Mandelate (6/22/50)	15	1.2	1	99	1	99	19	82	—	—	6	83
Dibutyl Adipate (6/22/50)	15	1.4	0	100	1	99	0	100	—	—	1	98
Untreated			112	—	141	—	122	—	—	—	46	—
Hexyl Mandelate (6/29/50)	15	1.2	14	81	—	—	—	—	2	96	—	—
Dibutyl Adipate (6/29/50)	15	1.6	5	94	—	—	—	—	2	96	—	—
Untreated			74	—	—	—	—	—	57	—	—	—

[1] *Aerosols:* 5% Chemical, 10% *Deobase*, 85% *Freon 11* and *12*; 15% Chemical, 85% *Freon 11* and *12*

2 grams per kilogram of body weight. Emulsifier *A* was used. The dogs were kept on leash and an untreated dog accompanied a treated one during exposure periods. The entire body was examined shortly after exposure and usually 24 hours later to uncover any ticks that had escaped detection during the first examination.

The initial trial (Table 5) of emulsions on dogs with both dibutyl adipate and hexyl mandelate was unsatisfactory. This was thought to be due in part to inadequate wetting of hair and skin. Consequently, a test was made in which yellow soap was added to the emulsion to increase the wetting action. This resulted in fairly good protection when tried the day following treatment. When the dogs were exposed to ticks a week later, however, no protection was evident. It is estimated that there was a gradual decrease in repellency so that, for dogs, retreatment with these materials might be necessary every 3 or 4 days.

AEROSOLS ON DOGS.—Fairly good protection for one day was obtained (Table 6) from aerosols containing 10 and 15 per cent hexyl mandelate and dibutyl adipate. A test made 1 week later (not shown in the table) indicated that the chemicals were no longer effective. It should be mentioned that the dogs appeared to be nervous and frightened during the aerosol treatment. This might have been overcome if the treatments had been continued and the animals had become accustomed to the cooling effect of the propellent and the sound of the spray as it was being released.

For the most part, however, treatment of dogs with hexyl mandelate or dibutyl adipate in either emulsion or aerosol forms resulted in a relatively short period of protection and may be suitable only for emergency use.

TOXICOLOGICAL ASPECTS.—Tests conducted at Mellon Institute indicated that when dibutyl adipate was fed to rats the L.D. 50 was 12.93 gm./kg. In a wear test, (Food and Drug Administration type), no progressive skin damage occurred on rabbits from drill cloth impregnated with 1.0 and 2 gm./sq. ft. Some initial erythema occurred but at 21 days the erythema was residual in

Table 5.—Tick repellency tests using emulsions on dogs.[2]

DOGS TREATED 6/7/50[1]	EMULSIFIER	After 1 Day		After 1 Week	
		No. Ticks	% Rep.	No. Ticks	% Rep.
Dibutyl Adipate	*Emulsifier A*	104	30		
n-Hexyl Mandelate	*Emulsifier A*	118	20		
Untreated		148			
6/13/50					
Dibutyl Adipate	*Emulsifier A*+Yellow Soap	14	93	200	0
n-Hexyl Mandelate	*Emulsifier A*+Yellow Soap	39	81	175	0
Untreated	*Emulsifier A*	200	—	188	—

[1] 2 gr. chemical per kg. body weight from concentrate of 90 parts chemical to 10 parts *Goremul A* diluted 1 to 16 parts water.
[2] Short haired fox terrier used for hexyl mandelate treatment. Beagle used for dibutyl adipate treatment.

Table 6.—Tick repellency tests using aerosols on dogs.[2]

Date and Chemical	Per Cent[1] in Aerosol	Grams Chem. per Kg. Animal	Fresh		After 1 Day	
			No. Ticks	% Rep.	No. Ticks	% Rep.
6/22/50						
Dibutyl Adipate	10	1.2	10	88	19	85
n-Hexyl Mandelate	10	1.3	14	83	16	87
Untreated			80	—	128	—
6/29/50						
Dibutyl Adipate	15	1.5	20	88	—	—
n-Hexyl Mandelate	15	1.8	6	95	—	—
Untreated			148			

[1] *Aerosols:*
10% Chemical
5% *Deobase*
85% *Freon 11* and *12*

15% Chemical
85% *Freon 11* and *12*

[2] Short haired fox terrier used for n-hexyl mandelate treatment. Beagle used for dibutyl adipate treatment.

character. The rabbits returned to normal 7 days later; these animals gained in weight during the test. The hazard from skin penetration is negligible; the LD 50 for rabbits was over 20 ml. per kg. when the chemical was held under a plastic sheet in contact with the skin. Dibutyl adipate was not particularly irritating to rabbit skin or eyes and is considered to be in the same category as chemicals suitable for use as insect repellents to be applied to the skin. Twenty-three applications in 80 days at 2 ml. dibutyl adipate per kilogram body weight resulted in slight skin desquamation on 2 of 4 dogs. The area affected was confined to the heavy hair over the shoulders, and there was no evidence of erythema. Weights were normal.

Tests, also conducted at Mellon Institute, indicated that when a 50 per cent dispersion of n-hexyl mandelate in Emulsifier *A* was fed to rats the LD 50 was 12.93 (9.85 to 16.97) gm./kg. This chemical is, however, more irritating than dibutyl adipate. In the Food and Drug Administration's type wear test with bandages impregnated at the rate of 2.0 gm./sq. ft. there was initial spotty erythema, which proceeded to minor erythema and desquamation. At 4.0 gm./sq. ft., a continuous band of marked erythema encircling the trunk was noted after 3 days of wear. Slight residual erythema or desquamation persisted throughout the remainder of the period, 20 days.

Skin penetration of the undiluted compound is of a low order. The LD50 for rabbits was 15.4 (13.3 to 17.8) ml./kg.

Seven treatments with a formulation of n-hexyl mandelate were made on dogs at 2 ml./kg. Three of the four treated dogs had irritated skin over the shoulders and along the back.

In general, it appears that dibutyl adipate can be used safely on clothing at 2 gr./sq. ft. or on dogs at 2 ml./kg. Frequent application to dogs may cause skin irritation. n-Hexyl mandelate may cause skin irritation at these levels from repeated use of treated cloth or when applied directly on dogs.

SUMMARY AND CONCLUSIONS.—Impregnation of coveralls and trousers with an emulsion containing dibutyl adipate resulted in 90 to 100 per cent protection against American dog ticks for several weeks when 2 grams of chemical was applied per sq. ft. of clothing. Almost as good results were obtained with hexyl mandelate used in the same way. Once impregnated, these chemicals persist, since even two washings failed to reduce their effectiveness. It was also found that any of three different emulsifiers could be used with dibutyl adipate without affecting the repellency of the emulsion.

Aerosol treatments of clothing with both dibutyl adipate and n-hexyl mandelate revealed that this method of application may have especial merit, as it is effective, rapid and easy to use. Dibutyl adipate was preferred because of its lack of irritation and odor in the mist form. Both of these chemicals provided fair protection for one day when applied to dogs in either the emulsion or aerosol form. Reapplication to these animals

would be necessary every few days, however, for continued protection.

From the toxicological viewpoint, it would appear that dibutyl adipate when used in applications of 2 g./sq. ft. on clothing worn by humans would not be harmful nor cause skin irritation. Frequent application of 2 ml./kg. body weight on dogs may cause skin irritation. n-Hexyl mandelate at these levels might be irritating when used repeatedly.

LITERATURE CITED

Cole, **Moses M.**, and Carroll N. Smith. 1949. Tick Repellent Investigations at Bull's Island, S. C. 1948. JOUR. ECON. ENT., Vol. **42**, No. 6, pg. 880–3.

Granett, Philip and Carl F. French. 1950. Field Tests of Clothing Treated to Repel American Dog Ticks. JOUR. ECON. ENT., **43** (1): 41–4.

Further Evaluation of Butoxypolypropylene Glycol as a Fly Repellent for Dairy Cattle[1]

PHILIP GRANETT, HARRY L. HAYNES[2] and ROBERT W. HELM,[3] *Rutgers University,*[4] *New Brunswick, N. J.*

The use of butoxypolypropylene glycols as repellents for flies attacking dairy cattle has already been reported (Granett *et al.* 1949). These compounds are of interest because, when formulated in oil or in water, they appeared to be effective against stable flies, *Stomoxys calcitrans* L., and horn flies, *Siphona irritans* L., on dairy cattle and against horse flies, *Tabanus* spp. This paper deals with further field tests with one of these compounds, butoxypolypropylene glycol 800.[5] It is of especial interest because of its low mammalian toxicity and lack of irritation.

CALCULATION OF PERCENTAGE REPELLENCY.—It is a recognized fact that animals vary in their susceptibility to fly attack and that this susceptibility may be influenced by a variety of physical, chemical, and physiological conditions and by densities of fly population. In some tests, an attempt to equalize this factor is made by grouping together cows of equal observed susceptibility, determined by counts of flies prior to the day of spraying. In the following experiments, possible change in susceptibility was taken into consideration by utilizing the fluctuation in counts of flies on the untreated check animals during the period that counts were being taken on treated animals.

Susceptibility to flies of each cow, including check cows, was determined by averaging three or more counts of flies on each animal prior to treatment or a short time after treatment was no longer apparently effective. If the counts on the untreated check cows vary from their susceptibility count during the test period it is assumed that the same forces causing this variation may also be acting on the treated cows (in addition to the treatment). Accordingly, the susceptibility counts of the treated cows are corrected proportionally upward if more flies are found on the checks, or downward if fewer flies are observed. This correction is termed the "corrected normal count" and may be represented by the following formula:

$$\text{Corrected normal count} = \frac{\text{Average count on checks (during test period)}}{\text{Average susceptibility count of checks}} \times \text{Susceptibility of treated animal}$$

Percentage repellency is computed in the usual manner, using the corrected normal count for comparison with the treatment.

$$\text{Percentage repellency} = \frac{\text{Corrected normal} - \text{Treatment count}}{\text{Corrected normal}} \times 100$$

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Department of Entomology.

[2] Now Senior Fellow in Entomology, Boyce Thompson Institute, Yonkers, N. Y.

[3] Now Assistant Extension Entomologist, Nebraska Exp. Sta., Lincoln, Neb.

[4] Investigations conducted under research fellowship sponsored by Carbide and Carbon Chemicals Division, Union Carbide and Carbon Corp. at Rutgers University and at Boyce Thompson Institute.

[5] Sold under the trade name of *Crag Fly Repellent* by the Carbide and Carbon Chemicals Div., New York City.

Table 1.—Repellency tests against horn flies on dairy cattle at New Brunswick, N. J., August, 1949.

	Avg. No. per Count[1]											
	On Day Sprayed				Day After			Day Resprayed			Day After			Day Resprayed		
Susc.[2]	Corr.[3] Norm.	Treatment	% Rep.[4]	Corr. Norm.	Treatment	% Rep.	Corr. Norm.	Treatment	% Rep.	Corr. Norm.	Treatment	% Rep.	Corr. Norm.	Treatment	% Rep.
Butoxypolypropylene glycol 800, 10% in *Deobase*															
156	111	4	97	92	31	66	132	10	93	106	66	38	59	6	90
Pyrethrins .07%, Piperonyl Butoxide .19%, in *Deobase*															
142	101	18	82	84	47	44	120	17	86	117	128	0	54	22	59
Untreated Check															
97		69			57			83			73			37	

[1] Sprayed 100 ml. per cow at 7 A.M.; counted at 2 hr. intervals beginning at 9:00 A.M. for 6 hours; 4 cows (Holstein, Brown Swiss, Ayrshire) per treatment.

[2] Susc. = Susceptibility of cows to fly attack determined from counts made 2 days previous to 1st spray.

[3] Corr. Norm. = Corrected normal count = $\frac{\text{Average Count on Check}}{\text{Average Susc. of Check}} \times$ Susc. of Treated Animals.

1st day	*2nd day*	*Respray*	*Day After*	*2nd Respray*
$\frac{69}{97} = .71 \times$ Susc. Tr.	$\frac{57}{97} = .59 \times$ Susc. Tr.	$\frac{83}{97} = .85 \times$ Susc. Tr.	$\frac{73}{97} = .75 \times$ Susc. Tr.	$\frac{37}{97} = .38 \times$ Susc. Tr.

[4] % Rep. = Percentage Repellency = $\frac{\text{Corr. Norm.} - \text{Treatment Count}}{\text{Corr. Norm.}} \times 100$

All the sprays were applied with an electric sprayer when the cows were in stanchions. Adjacent cows were covered with a canvas to prevent contact with spray drift. Immediately after spraying, the animals were released and placed in pasture where the fly counts were made.

TESTS IN NEW JERSEY IN 1949.—In one series of tests an attempt was made to determine whether spraying every other day for a short period would increase the residual repellency on the day following spraying. The tests were made in August against horn flies on dairy cattle. Butoxypolypropylene glycol 800 was used at 10 per cent in a highly refined kerosene type oil[1]. For comparison, in addition to the untreated cows, a combination of pyrethrins .07 per cent and the synergist piperonyl butoxide 0.19 per cent in *Test Oil 1* was used. The results, shown in table 1, indicated that, for the limited time of the experiment, no build-up in repellency was noted. The repellency for the butoxypolypropylene glycol 800 compound was more than 90 per cent on the day of spraying, but dropped markedly on the following day. The pyrethrins combination was less effective than the glycol compound on day of spray and on day after.

TEST IN NEW YORK, AUGUST 1949.—

[1] Test oils used were
Oil #1, *Deobase*
Oil #2, *Bayol D*
Oil #3, Mineral Seal Oils
Proprietary *Oils A* and *B*.

Table 2.—Repellency tests against stable flies and house flies on dairy cattle at Yonkers, N. Y., August, 1949.

	Avg. No. per Count[1]												Avg. for 5 Day Period		
	Day After Spray			Day After Respray			2nd Day After			4th Day After					
Susc.[2]	Corr.[3] Norm.	Treatment	% Rep.[4]	Corr. Norm.	Treatment	% Rep.	Corr. Norm.	Treatment	% Rep.	Corr. Norm.	Treatment	% Rep.	Corr. Norm.	Treatment	% Rep.
Butoxypolypropylene glycol 10% in Test Oil #1															
20	21	6	72	22	5	77	46	16	65	18	11	39	27	10	63
Proprietary Spray 1[5]															
22	23	20	13	24	15	38	51	36	29	20	19	5	30	23	23
Proprietary Spray 2[6]															
20	21	16	24	22	14	32	46	39	15	18	19	0	27	22	19
Untreated Check															
22		23			24			52			20			30	

[1] Sprayed 100 ml. per cow at 4 P.M. and counts made at 2 hr. intervals for 8 hours beginning at 9:00 A.M. the following day; 8 cows (Guernsey) per treatment.

[2] Susc. = see Note 2, Table 1.

[3] Corr. Norm. = see Note 3, Table 1.

1st Day Count	*2nd Day Count*	*3rd Day Count*	*5 Day Count*	*Avg. for Period*
$\frac{23}{22} = 1.04 \times$ Susc. Tr.	$\frac{24}{22} = 1.09 \times$ Susc. Tr.	$\frac{52}{22} = 2.3 \times$ Susc. Tr.	$\frac{20}{22} = .9 \times$ Susc. Tr.	$\frac{30}{22} = 1.36 \times$ Susc. Tr.

[4] % Rep. = see Note 4, Table 1.

[5] "Unico"—.03 Pyrethrins, .25 Tech. Piperonyl butoxide.

[6] 5% Pyrenone New in *Deobase*

Table 3.—Repellency tests against horn flies on dairy cattle in Middletown, Delaware, July, 1949.

Material and Concentration	Number[1] and Percentage Repellency[2]									
	1st Day		2nd Day		Reapplied 3rd Day		4th Day		Avg. for 4 Day Period	
	No.	% Rep.	No.	% Rep.	No.	% Rep.	No.	% Rep.	No.	% Rep.
Butoxypolypropylene glycol 10% in *Test Oil 1*	12	90	21	73	2	97	8	90	11	88
Butoxypolypropylene glycol 10%, Pyrethrins .05% in *Test Oil 1*	2	99	18	77	1	99	5	93	7	92
Butoxypolypropylene glycol 5%, *Thanite* 2% in *Test Oil 1*	1	99	24	70	1	99	7	88	8	91
Thanite 3% in *Test Oil 1*	4	97	71	9	3	96	30	62	27	70
Proprietary Spray 3[3]	.5	99	25	68	2	97	10	87	9	90
Methoxychlor 0.5% in water	2	98	10	87	2	98	4	95	5	94
Untreated Check	122		78		79		79		90	

[1] Sprayed 100 ml. per cow at 7:00 A.M. and 30 ml. per cow on 3rd day; counts begun at 9:00 A.M. and were made at hourly intervals, usually until 6:00 P.M.; 2 cows (Guernsey, Holstein or Brown Swiss) per treatment.
[2] Per cent repellency based on untreated check.
[3] "*Gulf Spray*" .07% Pyrethrins, .19% Tech. Piperonyl butoxide in petroleum distillate.

A somewhat similar test was made against stable and house flies at Yonkers, N. Y. In this test (Table 2), the cows were sprayed on one day and resprayed the following day. It should be noted, however, that the sprays were applied at 4:00 P.M. and counts begun on the following day, so that 17 to 18 hours elapsed between application and time of counting. Counts were continued for 3 days following the last spray. Comparison was between 10 per cent butoxypolypropylene glycol 800 and two synergized pyrethrins containing proprietary sprays.[2] In general, somewhat better protection was obtained from the glycol containing spray on the second day under these conditions than was obtained against horn flies in New Jersey.

TESTS IN DELAWARE, JULY 1949.—In this series (Table 3) comparison was made between 10 per cent butoxypolypropylene glycol 800 in oil with a similar glycol content plus pyrethrins (.05%) and also with the glycol combined with isobornyl thiocyanoacetate.[1] A proprietary spray

[1] *Thanite*, Hercules Powder Co.
[2] *Unico*—.03 pyrethrin, .25 Tech. Piperonyl butoxide in Petroleum Oil United Cooperative, Philadelphia, Penna. (Spray 1); 5% *Pyrenone 20 New* in *Deobase*—*Pyrenone New* contains .62% Pyrethrin and 5.03% Tech. Piperonyl butoxide—U. S. Industrial Chem. Corp., Baltimore, Md.

Table 4.—Repellency tests against horn flies on dairy cattle at New Brunswick, N. J., July, 1950.

5% Butoxypolypropylene Glycol .05% Pyrethrins in Base Oil Noted Below	Avg. No. per Count[1]						
	On Day Sprayed				Day After Spray		
	Susc.[2]	Corr.[3] Norm.	Treatment	%[4] Rep.	Corr. Norm.	Treatment	% Rep.
Test Oil 1	132	75	18	76	50	50	0
Test Oil 2	149	83	16	81	57	50	12
Test Oil 3	163	93	23	75	62	48	23
Oil A	132	75	7	90	50	30	40
Oil B	144	82	11	86	55	55	0
Untreated Checks	111		63		42		

[1] Sprayed 100 ml. per cow at 7:00 A.M. on July 13, 17 and 20 and counts beginning at 11:00 A.M. made at 2 hr. intervals day of spraying and following day until 3 P.M. A total of 6 cows (Guernsey, Holstein or Brown Swiss) used for each treatment. Four cows used each day for checks not sprayed during test period.
[2] Susc. = Susceptibility of cows to flies determined from 17 counts made on July 6, 7, 19, 24, and 25.
[3] Corr. Norm. = see note 3, Table 1.

Day of Spraying: $\frac{63}{111} = .57 \times$ Susc. Tr.

Day After Spraying: $\frac{42}{111} = .38 \times$ Susc. Tr.

[4] % Rep. = See Note 4, Table 1.

Table 5.—Properties of oils tested.

	Oil 1	*Oil 2*	*Oil 3*	*Oil A*	*Oil B*
A.P.I. Gravity	49/51		33.5		37
Sp. Gr.	.775	.8	.845		.839
Flash Pt. °F.	170°	160°	250		260
Say. Viscosity	30–35	32	45	38–40	40–45
Initial Boiling Point °F.	370–390	400	535		
Final Boiling Point	480–500	505	680		
Say. Color	30+	25			
Unsulfonated Residue Vol. %	97	97			
Per Cent Aromatics		<1			
Odor	Practically none	Practically none	Practically none	Slight	Practically none

containing 0.07 per cent pyrethrins plus 0.19 per cent technical piperonyl butoxide in a petroleum distillate and wettable powder of methoxychlor at 0.5 per cent in water were also included. An attempt was made to use pairs of cows that were equally susceptible to fly attack.

One hundred ml. were sprayed on the first day and 30 ml. resprayed on the third day. Excellent protection, more than 90 per cent, was obtained on the day of spraying in each case. On the day following spraying, fair to good repellency was obtained from all the oil sprays except isobornyl thiocyanoacetate used alone. Methoxychlor maintained a uniformly high degree of protection during the 4-day period.

TESTS IN NEW JERSEY 1950.—Freeborn in 1932, and others since then, have observed that the base oil used in cattle fly repellency tests influences the repellency of the products being tested. An oil which did not mask the relative repellency of added ingredients would be useful when the evaluation of the individual ingredients was desired. On the other hand, when it was necessary to get as high a level of repellency as possible, as under practical conditions, it would be desirable to use an oil which might also contribute to the repellency of the mixture. *Test Oil 1* has been used for many of the experimental formulations because of its availability and general lack of toxic or irritating effects. Four other oils were selected for comparison with *Oil 1*. These were *Oils 2* and *3* and proprietary *Oils A* and *B*.

Some of the physical and chemical characteristics of these oils are tabulated in table 5.

In the first series of sprays, butoxypolypropylene glycol 800 at 5 per cent and pyrethrins at 0.05 per cent were combined

Table 6.—Repellency tests against horn flies on dairy cattle at New Brunswick, N. J., July and August, 1950.

5% BUTOXYPOLYPROPYLENE GLYCOL AND .05% ALLETHRIN IN BASE OIL NOTED BELOW	AVG. NO. PER COUNT[1]						
	Day Sprayed				Day After Spray		
	Susc.[2]	Corr.[3] Norm.	Treatment	% Rep.[4]	Corr. Norm.	Treatment	% Rep.
Oil 1	82	74	17	77	69	68	0
Oil 2	91	82	9	89	77	55	29
Oil 3	66	60	7	88	56	41	27
Oil A	90	81	6	92	76	53	30
Oil B	77	69	11	84	65	45	31
Untreated Checks	72		67			61	

[1] Sprayed July 27, 31 and August 7. See footnote 1, Table 4.
[2] Susc. = Susc. of cows to flies determined from 5 counts made August 2, 9 and 10.
[3] Corr. Norm. = See Note 3, Table 1.

Day of Spraying

$$\frac{67}{72} = .93 \times \text{Susc. Tr.}$$

Day After

$$\frac{61}{72} = .85 \times \text{Susc. Tr.}$$

[4] % Rep. = see Note 4, Table 1.

Table 7.—Repellency tests against horn flies on dairy cattle at New Brunswick, N. J., August, 1950.

MATERIALS AND CONCENTRATIONS	AVG. NO. PER COUNT[1]						
	Day Sprayed				Day After		
	Susc.[2]	Corr.[3] Norm.	Treatment	% Rep.[4]	Corr. Norm.	Treatment	% Rep.
Butoxypolypropylene glycol 5% plus *Thanite* 3%, in *Oil 2*	147	80	5	94	75	35	54
Butoxypolypropylene glycol 5% plus Allethrin .05%, in *Oil 2*	136	74	19	74	75	66	12
Butoxypolypropylene glycol 10% plus Allethrin .05%, in *Oil 2*	134	72	14	81	73	45	38
Proprietary Spray 3[5]	125	68	5	93	69	33	52
Check-Untreated	96		52			53	

[1] Sprayed 100 ml. August 16, 21 and 24. See note 1, Table 4.
[2] Susc. = Susc. of cows to flies determined from 9 counts made on August 23, 28 and 29.
[3] Corr. Norm. = See Note 3, Table 1.

Day of Spraying: $\frac{52}{96} = .54 \times$ Susc. Tr.

Day After: $\frac{53}{96} = .55 \times$ Susc. Tr.

[4] % Rep. = See Note 4, Table 1.
[5] "*Gulf Spray.*"

in each of the various oils and sprayed at 100 ml. per cow. The sprays were run in duplicate and applied on three different days, a total of six different cows being used. The summarized results of counts made on the day of spraying and on the following day are recorded in table 4. These results indicate that on the day of spraying, *Oils 1* and *3* sprays were least effective. Sprays based on *Oil A*, *Oil B* and *Oil 2* provided more than 80 per cent protection. The ingredients carried by *Oil A* provided a low order of residual repellency on the following days; the other sprays were ineffective.

In the second series of sprays with the base oils, butoxypolypropylene glycol 800 at 5 per cent was combined with allethrin at 0.05 per cent. In this series (Table 5), the *Oil 1* spray again gave the lowest percentage repellency for both days on which counts were taken. *Oil A* was again highest, with 92 per cent repellency on day of spray, followed by *Test Oil 2* and *3* and *Oil B*. Although *Oil A* spray showed up best on the following day, there was actually little difference in effectiveness of the best four oil sprays. It is interesting to note that allethrin in this series contributes to general repellency at least as much as an equivalent amount of pyrethrins.

Oil 1 appears to be a good oil to use if the tester wants to know the maximum contribution of the added ingredients in an oil repellent spray. It is not so desirable if maximum repellency is wanted from a given formulation for practical use.

Table 8.—Repellency tests against horn flies on dairy cattle at New Brunswick, N. J., August and September 1950.

MATERIALS AND CONCENTRATIONS	AVG. NO. PER COUNT[1]									
		Day of Spray			Day After Spray			2nd Day After Spray		
	Susc.[2]	Corr.[3] Norm.	Treatment	% Rep.[4]	Corr. Norm.	Treatment	% Rep.	Corr. Norm.	Treatment	% Rep.
Butoxypolypropylene glycol 2.5% plus *Thanite* 1.5% in water emulsion	127	147	5	96	114	21	82	97	23	76
Butoxypolypropylene glycol 2.5% plus *Thanite* 1.5% plus Bentonite-Sulfur 5% in water	158	183	6	97	142	41	71	108	75	30
Butoxypolypropylene glycol 5% plus *Thanite* 3% in *Bayol D*	125	145	6	96	112	35	69	95	37	61
Untreated Check	66		77			60			50	

[1] Sprayed 200 ml. per cow of emulsions and 100 ml. of oil base spray at 7:00 A.M. on August 31 and September 5. See Note 1, Table 4.
[2] Susc. = Susceptibility of cows to flies determined from 9 counts made August 28, 29 and September 4, 1950.
[3] Corr. Norm. = See note 3, Table 1.

Day of Spraying: $\frac{77}{66} = 1.16 \times$ Susc. Tr.

Day After Spray: $\frac{60}{66} = .9 \times$ Susc. Tr.

2nd Day After: $\frac{50}{66} = .76 \times$ Susc. Tr.

[4] Per cent Rep. = see Note 4, Table 1.

TESTS WITH *Test Oil 2* AS BASE OIL.—Because of the results of the foregoing tests, and because it was available and appeared to be blander than *Oil A*, *Oil 2* was used as the base oil in the series of tests shown in table 6. The procedure of the tests was the same as in the previous two series. It was found that a combination of butoxypolypropylene glycol 800 at 5 per cent plus isobornyl thiocyanoacetate at 3 per cent was slightly more effective than the pyrethrin proprietary spray on both days of counting and also more effective than two combinations of glycol and allethrin.

EMULSION SPRAYS COMPARED WITH OIL BASE.—Cuff (1949) reported that the use of bentonite sulfur[1] resulted in an increased repellency of the formulations he was using. It was thought desirable to know whether use of this product as a possible sticker or adjuvant would increase repellency under New Jersey conditions. A water emulsion consisting of 2.5 per cent butoxypolypropylene glycol 800, 1.5 per cent isobornyl thiocyanoacetate and 0.5 per cent emulsifier[1] was compared to a similar emulsion containing, in addition, 5 per cent bentonite sulfur. It will be noted in table 7 that 200 ml. of these emulsions were applied to each cow so that the emulsion treatment could be compared with an oil spray containing similar repellent ingredients. The bentonite sulfur was not included in the oil spray. These tests were run in duplicate and applied on two different days so that a total of four cows received each spray. Counts were continued to the third day after spraying. It was found that the emulsions were as effective as the oil-carried spray. No difference in effectiveness was apparent between the emulsion with or without the bentonite sulfur during the first two days of counting and on the third day the effectiveness of the bentonite sulfur spray had dropped below that of the others. It will be noted that in general the percentage repellency of these treatments was higher than is usually encountered in this area with these materials, but is in line with results reported in Florida. (Granett *et al.* 1949).

SUMMARY AND CONCLUSIONS.—Field tests with butoxypolypropylene glycol 800 in oil and water emulsion combination with pyrethrins, allethrin or Thanite were made in New York, New Jersey, and Delaware. Applications were made on dairy cattle against horn, stable, and house fly infestations. A method of computing percentage repellency is noted which takes into consideration possible fluctuations in the cow's susceptibility to fly attack. It was found that combinations containing 5 to 10 per cent butoxypolypropylene glycol 800 were highly effective on the day of application, but that this protection generally dropped off on the following day. Such combinations were generally equal or superior to formulated or proprietary sprays containing synergized pyrethrins. The base oil used in formulating repellent sprays has a definite effect on the resulting repellency and can be selected so that it causes least interference with evaluation of a series of repellent ingredients or it can be selected to give maximum possible effectiveness necessary for practical use.

Although emulsions containing butoxypolypropylene glycol appeared as effective as oil base spray, the addition of bentonite sulfur as a sticking agent did not increase repellency.

LITERATURE CITED

Cuff, Ray L. 1950. Fused bentonite sulphur to prolong horn fly protection on beef cattle. JOUR. ECON. ENT. **43**(1): 111.

Freeborn, S. B. and W. M. Regan. 1932. Fly sprays for dairy cows—A Progress Report. JOUR. ECON. ENT. **25**(2): 167–74.

Granett, Philip, Harry L. Haynes, Donald P. Connola, Thomas G. Bowery and George W. Barber. 1949. Two butoxypolypropylene glycol compounds as fly repellents for livestock. JOUR. ECON. ENT. **42**(2): 281–6.

SCIENTIFIC NOTES

Honey Bee Activity on Ladino Clover Florets

GEORGE H. VANSELL, *Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture*[1]

The production of Ladino clover seed on irrigated land in the Sacramento Valley of California is expanding rapidly. The increase in alfalfa seed yield was so phenomenal when five colonies of bees per acre were placed in the fields during 1949 that the same numbers were placed in some Ladino clover fields in 1950. Some of the bees had to be fed to prevent starvation.

Certain basic differences exist between alfalfa and Ladino clover. Blossoms appeared on Ladino clover only a few days after clipping instead of after about 30 days, as with alfalfa. This is because the individual clover blossom shoots rise from the very low crown of the plant. An alfalfa blossom trips with explosive violence after the rigid holding mechanism is forcibly released, whereas the Ladino staminal column protrudes easily and gently with the natural approach of each bee. Millions of florets per acre are open continuously on alfalfa in bloom, but relatively few were found on the Ladino, and these during only part of one day.

Recent observations made on the University of California Farm at Davis indicate that a small number of bees is sufficient for practically complete pollination of the clover florets. In addition, even with relatively few colonies, very little honey can be expected.

Table 1.—Number of pods and seeds formed in individual heads during exposed and bagged periods

Exposed Period			Bagged Period		
Pods	Seeds	Seeds per Pod	Pods	Seeds	Seeds per Pod
43	107	2.48	66	2	0.03
61	171	2.80	26	0	0.00
58	194	3.34	42	5	0.11
50	92	1.84	71	0	0.00
69	155	2.25	50	2	0.04

No clover buds opened at Davis until about 9:30 in the morning, and very few opened before 11. After this time the florets opened intermittently until evening. From 3 to 15 florets per head opened daily; the average number for a series of heads was 8.2. Under the field conditions here nearly all the blossoms visited turned pink, and all of them closed permanently at nightfall. During warm, dry weather an alfalfa floret closes 2 hours after being tripped by a bee; but the Ladino clover floret does not, and when the individual heads were protected by paper bags against bee visitation the blossoms remained open during the night and continuously for several days.

Since nectar was not found in any of 1,000 freshly opened florets, a series of heads were bagged and the florets examined periodically for nectar. By 1 P.M. from 33 to 50 per cent of the florets had only a trace of visible nectar; at midafternoon 75 to 100 per cent showed a trace of nectar. An occasional floret had no visible nectar at 5 o'clock. However, by the next morning all the florets on the bagged heads had nectar. During the following days nectar accumulated to such an extent that a large droplet was plainly visible.

There were 66 to 158 florets in the 44 heads examined; about 100 was the average number. The range of seeds found in mature heads selected at random was 129 to 338, the average being 247.6. When heads were bagged throughout the blossoming period, practically no seeds formed. The yields from 5 such heads were 0, 0, 0, 0, and 2 seeds. An example of seed found in heads bagged during part of the flowering period appears in Table 1. The presence of seeds in the pods corresponded to the period of exposure to bee activity.

Most of the pods in open-pollinated heads contained either 2 or 3 seeds, but occasionally one carried 6. Table 2 shows the distribution of seeds in 8 heads.

Honey bees were not present on the clover until about 9:30 A.M.; after that time they visited it continuously until nearly sundown. At the height of visitation in midafternoon, 2 or 3 bees per square yard were frequently present. Two bees per yard is roughly the equivalent of 2.5 pounds of bees per acre. A good colony contains at least three times this weight of bees.

Pollen was the chief interest, judging by the fact that all bees observed for some time gradually accumulated pollen in the corbiculae, and the apparent lack of nectar in the blossoms for some time after they opened. The staminal column of the flower protruded from its hidden position to contact gently and withdraw from each bee visitor. Individual florets were visited time after time during the day. Honey bees were also observed to force their probosces into buds not yet fully open. All open blossoms were visited and presumably pollinated daily; such blossoms did not reopen the second day.

The chance of securing honey from Ladino clover in this area is negligible, judging from the small number of open blossoms on a head and the lack of visible nectar until afternoon.

Table 2.—Distribution of seeds in open-pollinated heads.

Number of Pods with Seeds Indicated							Total Number	
None	1	2	3	4	5	6	Pods	Seeds
7	9	42	41	18	1	0	119	297
3	16	31	49	17	0	0	116	293
11	14	30	34	18	7	1	116	291
7	18	32	32	13	2	1	106	246
11	20	45	38	19	0	0	133	300
8	10	12	27	33	13	1	104	318
8	15	20	28	15	5	0	91	224
18	28	41	39	15	2	0	143	388

[1] In cooperation with the University of California.

A Method of Testing the Resistance of House Flies to Residual-Type Insecticides

DALE R. LINDSAY,[1] and THOMAS W. HAINES,[2] *Communicable Disease Center,[3] Public Health Service, Federal Security Agency, Atlanta, Ga.*

Since the recognition of resistance of house flies, *Musca domestica* L., to DDT and to other halogenated hydrocarbons used as insecticides, several methods have been used successfully to evaluate the degree of resistance attained in wild fly populations. The two most widely used of these methods have involved the field collection of fly eggs from naturally occurring media or of adult flies for oviposition. In either instance the test flies were the reared adults, making the test period follow the field collection by some three weeks but allowing a uniform age comparison with susceptible colony flies. Either method made possible the shipment of eggs or maggots to a central laboratory where uniform testing facilities existed.

In the course of field studies being conducted in southwest Georgia it became apparent that a faster method of determining the resistance existing in the field was desirable in order to permit the earliest discontinuance of ineffective insecticides. The method described below was found to yield satisfactory evaluation of fly resistance to several insecticides simultaneously within a period of forty-eight hours after they were collected in the field. This rapid determination of the degree of resistance shown by the field flies to several insecticides permits a prompt change to the most effective test insecticide before the fly infestation becomes markedly heavier, thus preventing a waste of materials. It also standardizes test surfaces and variables other than those inherent in the flies themselves.

DESCRIPTION OF METHOD.—Flies are collected in the field by two methods. The cone net described by Maier & Dow (1949) has been modified to permit better manipulation of the small collection cages.

Instead of a one-inch opening at the top of the cone, a sheet metal throat, 3 inches square in cross section and 4 inches long, has been substituted. This throat extends into a horizontal sheet metal panel designed to receive a similar panel upon which each collection cage is mounted. The cages are square in cross section in order to take full advantage of the square opening in the throat of the cone net, although a circular opening in each would serve equally well. The opening into the collection cage may be adjusted to regulate the filling of the cage as desired, and one cage may be filled from several settings of the cone net or several cages may be filled in rapid succession when flies are abundant upon any one attractant. The cone net usually will permit collection of sufficient numbers of flies for testing and is particularly effective when flies are concentrated upon attractants. As previously reported, flies thus caught are damaged very little in handling.

A second device found useful is a sweep net with a clear plastic cone inserted just below the rim of the net and provided with a central opening about one inch in diameter. This net serves to hold the flies caught without necessitating the closing of the net. When flies are dispersed over widespread attractants or inside of barns or other animal enclosures, they can be collected most efficiently with a sweep net. With care and a little practice the flies thus caught can be transferred to holding cages with a minimum of injury.

Of perhaps the greatest importance, particularly during hot weather, is the manner of holding and transporting collected flies to the field laboratory. A simple insulated box with racks for holding the field cages over wet ice is used and permits the collector to accumulate flies for several hours without ill effect to the flies.

When the collecting cages of flies are delivered to the laboratory they are placed on shelves and the flies fed honey-water. An 18 to 24-hour holding period is advised before beginning the tests for insecticide resistance. During this holding period injured or weak flies succumb, as well as flies affected by such insecticides as they may have contacted in the field. In fact, the percentage mortality during this holding period is a useful tool in determining the field effectiveness of the insecticide being used in the area and supplements the data later obtained from the tests. In addition, the holding period provides a uniform feeding period for all the test flies.

At approximately the same time that the flies are being collected, the insecticide solutions are applied to the petri dishes used as test chambers. Solutions of insecticides may be prepared in quantity for several weeks of testing as long as very dilute insecticide solutions in commercial solvents, such as acetone, are avoided. Extreme dilutions with these commercial solvents should be made just prior to their use, otherwise the traces of acid in the solvent may deteriorate the likewise small traces of insecticide. Serial dilutions using the same solvent as in the concentrate are satisfactory for this purpose. Preliminary tests to determine the dosage and the exposure time should be made to establish the proper combination for the desired mortality ranges in susceptible flies. Standard-sized petri dishes are used for all tests and the treatment dosage converted to milligrams per square foot. Use of a 10 cc. syringe, in spite of frequent refilling, has proven more accurate and faster than have burettes or pipettes in applying the insecticide solution. In working out this method, acetone proved to be an excellent solvent. In applying the treatment the insecticide solution is allowed to flow over the entire flat surface by tilting the dish. The lip of the inside dish is treated by a single tilted rotation of the dish so that the solution covers the lip surface. When the solvent has evaporated and the dishes are closed they are inverted so that the cover dish is the bottom surface, facilitating ease in handling.

After the holding period the dead flies are removed from the field collection cages by shaking them to one side of the sliding bottom panel. When the panel is opened about one-fourth inch the dead flies can be shaken out and properly boxed with appropriate identification for later species and sex determination. The remaining live flies are anesthetized in an atmosphere of CO_2 gas by inverting the cage in an open-topped metal container just larger than the screen cage. Fifteen to twenty seconds exposure is usually sufficient for complete knockdown. The field cage is then opened by removing the bottom sliding panel and the flies are poured into a petri dish and placed in a second CO_2

[1] Scientist.
[2] Senior Assistant Sanitarian. (R)
[3] From Entomologic Services, Thomasville Station Section, Thomasville, Ga.

anesthesia chamber. This chamber has a sliding glass panel mounted in the front and inclined about 30 degrees from the vertical to facilitate vision. Other features of the chamber include elastic-cuffed plastic sleeves, so that the hands and forearms of the operator may be inserted in the chamber, and a fluorescent light mounted in the top just under and behind the sliding glass panel. Sorting to common species by sexes is easily performed without magnification.

Simultaneous testing of several insecticides may be easily accomplished by the following procedure. When the flies from a cage have been placed in the anesthesia chamber, a number of watch glasses corresponding to the number of tests are aligned along the front of the chamber. If four insecticides are being tested then five watch glasses per sex, or ten in all, including a check or solvent blank test, are used. The flies from the field cage are then sorted by sex into equal components of the test species in each dish. Thus, if the cage contained over 200 house flies, equally divided as to sex, in addition to several other species, this one cage would provide enough house flies for the 10 dishes allowing a sample of 10 flies per test. If fewer flies are involved they are equally distributed and the necessary number of additional cages are handled similarly to provide the desired sample size. This technique insures uniform exposure to the CO_2 as well as uniform distribution of the flies from the different areas. Continuous anesthesia periods up to one hour have shown no adverse effect upon the flies. As many replications as desired may be made in this manner.

Valuable information regarding the species composition and sex distribution of the fly population sampled, locations of fly abundance, effect of the insecticide upon individual flies, etc., can be gained by recording other easily obtained data at the time of sorting. Such data are particularly valuable in comparing treated versus untreated areas.

When the watch glasses have been filled to the desired sample size they are emptied in uniform rotation into the test dishes and a new replication sorting is started. Exposure periods of five minutes to one hour have been used but middle ranges of twenty to thirty minutes are recommended. Short exposures increase the probability of error in the exposure time and also allow a nonuniform recovery from the anesthesia. Long exposure periods prolong the duration of the test excessively.

At the conclusion of the exposure period the flies are again anesthetized by introducing CO_2 gas through the overlapping lips of the petri dishes. Thin-walled rubber tubing of 0.375 to 0.5-inch inside diameter, connected to the CO_2 supply and compressed between the operator's thumb and first finger, serves very well to introduce the gas into the closed dish. Ten seconds or less per dish is usually sufficient for anesthetizing the flies and the process of anesthetizing can be completed on all dishes before they are emptied.

A very satisfactory holding cage for observing the effects of the test exposure, as long as the sample size does not exceed 50 flies, is a pint glass fruit jar with screen inserted under the cap ring in place of the sealing lid. These jars can be appropriately marked with a china marking pencil and the screened end provides a place to accommodate the honey-water soaked cotton ball for feeding. These jars have proven satisfactory for holding periods up to 72 hours without excessive check mortality.

An important part of the above technique is the thorough washing of the test glassware. By designing hardware cloth containers with properly spaced separators it is possible to wash the glassware in quantity with a minimum of breakage and handling of individual units. A proven method is to dip the washing rack of glassware several times into a vat of commercial xylene, remove, drain briefly and repeat the dipping successively through two changes of hot water containing a detergent, and lastly through a hot water rinse. It is important that the xylene should not dry on the glassware before it is submersed in the detergent water. The same xylene may be used for a considerable quantity of glassware after which it may be re-drummed for later use as a solvent in mixing emulsifiable insecticide concentrates. After the hot water rinse the glassware may be drained in the washing containers and toweled, if necessary, with clean cloth or paper towels as it is being removed for storage.

USE OF RESULTING DATA.—The primary advantage of this method is the fact that a reliable index of the fly resistance to an insecticide can be obtained within a 48-hour period and the insecticide discontinued if fly resistance to it is shown to be high, even though control may appear satisfactory. If tests show that the insecticide is still effective, although the degree of fly control is unsatisfactory, then other explanations for the poor control should be sought. Such things as incomplete spray coverage, gross fly breeding due to improper sanitation, etc., may result in poor fly control in spite of an effective insecticide. In these latter instances appropriate corrective action should be taken. This knowledge applied in selecting effective field insecticides is believed to more than offset the costs of the tests, providing that the area of control is a municipality or a group of agricultural production centers. For example, one laboratory could serve all the dairies in a county in assisting in the choice of effective insecticides.

SUMMARY.—A method of testing field collected flies is described which will lend itself to a variety of statistical sampling designs. It requires a minimum of specialized equipment, all of which can be easily procured or manufactured by the personnel involved in a fly control program. A supply of uniform size petri dishes and pint fruit jars constitute the biggest item of procurement. It is desirable to have a CO_2 dispenser, complete with pressure regulator and lines with shut-off valves to a field-cage anesthesia chamber, a sorting anesthesia chamber, and a rubber tube for applying gas to closed petri dishes, although simplified versions and uses can be made as expedient. Modified cone and sweep nets are desirable as are the easily interchanged field cages for use with the cone net and for holding the flies prior to the test.

The procedure involves the capture, with a minimum of injury, of a sample of several hundred flies from the test area, preferably representative of the entire area. These flies are held during subsequent field collecting in an insulated box over wet ice which minimizes over-heating and desiccation. A uniform holding period, selected from a range of 18 to 30 hours, before testing eliminates weak or insecticide-affected flies. Such flies are removed just prior to testing and their species and sex determined and recorded. The remaining live flies are anesthetized and sorted by species and sex for the tests desired. They are then exposed in previously treated

petri dishes for a uniform time interval after which they are transferred to pint jar containers and held for as long as desirable. Knockdown or kill after the test may be recorded at any desired interval although 24 and 48-hour records appear most logical and consistent when comparing various insecticides. Used glassware, as well as sheet-metal and screen equipment, are thoroughly washed before reuse.

The above method has proven valuable as a means of rapidly determining the progressive degrees of insecticide resistance of house flies, or any species of field flies, and also in providing a comparison of the flies from chemically treated versus untreated areas; both of the latter can then be compared with flies from standard laboratory colonies as desired. The determination of the selective effect of a specific insecticide upon a single fly species is useful in determining the value of this insecticide in the particular situation involved. The experience of the authors indicates that the cost of the testing may be easily amortized through savings effected in discontinuing use of ineffective insecticides and substituting effective ones.

LITERATURE CITED

Maier, P. P., and R. P. Dow, 1949. Diarrheal Disease Control Studies II. Conical net for collecting flies. Public Health Reports. 64(19): 604–07.

Synergism Between Nicotine and Pyrethrum

NEELY TURNER, *Connecticut Agricultural Experiment Station, New Haven*

Synergism between nicotine and pyrethrum has been found in the course of investigations of the action of insecticides applied jointly. These materials were injected into adult milkweed bugs in dosage series alone and jointly. Dosages of each sufficient to produce 25 per cent mortality killed all of the bugs when applied jointly.

Three series of tests were made using the injection method on adult milkweed bugs. In the first test (Table 1) dosage series of the two materials were applied alone and in combination.[1] There were six replicates of 12 bugs each for the materials alone, and 10 replicates of the two applied jointly. In the three proportions of joint application, the observed mortality was far larger than expected according to the calculation of Wadley (1945). For instance, 0.07 per cent nicotine killed 19 per cent of the bugs, and 0.0086 per cent pyrethrum, 11 per cent. The two applied together caused 87 per cent mortality.

The second type of test (Table 2) consisted of three relatively low dosages of nicotine and pyrethrum applied separately, and joint application of (1) the highest concentration of nicotine and the lowest of pyrethrum, (2) the lowest concentration of nicotine and the highest of pyrethrum, and (3) the intermediate concentrations of both, in dosage series. Unfortunately, the pyrethrum dosages were much less toxic than those chosen for nicotine. Any

Table 1.—Nicotine—pyrethrum synergism, injection method, milkweed bugs.

Material and Per Cent Conc.		Per Cent Mortality Replicate										Mean
		1	2	3	4	5	6	7	8	9	10	
Nicotine												
.2		67	92	75	75	75	83					78
.14		67	50	42	42	50	58					51
.1		25	25	25	8	50	25					26
.07		25	33	0	8	25	25					19
.05		17	25	8	0	8	0					10
.035		8	0	0	8	17	8					7
Pyrethrum												
.025		83	83	75	25	17	33					53
.0175		67	67	58	8	0	8					35
.0125		17	50	33	0	0	25					20
.0086		0	8	8	25	25	0					11
.0062		17	0	8	0	8	0					5
.0043		0	0	0	17	0	0					3
Nicotine Conc.	Pyrethrum Conc.											
.07	.0086	92	100	92	92	94	83	83	83	75	81	87
.05	.0125	100	100	100	92	98	83	50	58	83	69	83
.1	.0062	92	83	83	83	85	92	83	67	50	73	79

Calculation for Synergism (Wadley 1945)

Nicotine	Nicotine Equiv. Pyr.	Total Nicotine	Mortality Expected	Mortality Observed	Synergism
.07	.048	.118	48	87	+++
.05	.07	.120	48	83	+++
.1	.037	.137	54	79	++

Table 2.—Nicotine—pyrethrum synergism, injection method, milkweed bugs.

MATERIAL	CONC.	PER CENT MORTALITY, REPLICATE 1	2	MEAN
Nicotine	.1	58	75	67
	.07	17	50	33
	.05	8	8	8
Pyrethrum	.0043	33	17	21
	.0031	8	0	4
	.0021	0	0	0
Combinations Nicotine-Pyrethrum				
.1	.0021	92	67	79
.07	.0016	67	50	58
.05	.0011	17	42	29
.035	.0008	8	0	4
.025	.0005	25	0	12
.05	.0043	92	100	95
.035	.0031	75	75	75
.025	.0022	33	50	42
.0175	.0015	33	8	21
.0125	.0011	33	8	21
.07	.0031	93	67	79
.05	.0022	75	67	71
.035	.0015	67	58	63
.025	.0011	33	8	21
.0175	.0008	8	8	8

Calculation for Synergism (Wadley, 1945)

Concentrations Nicotine	Equiv. Pyr.	Total Nicotine	Mortality Expected	Observed	Synergism
.1	.0315	.1315	88	79	− − −
.07	.024	.094	60	58	− − −
.05	.0165	.0665	26	29	− − −
.035	.012	.047	2	4	− − −
.025	.0075	.0325	7	12	− − −
.05	.0645	.1145	78	96	++
.035	.0465	.0815	44	75	++
.025	.033	.058	15	42	++
.0175	.0225	.04	2.5	21	+++
.0125	.0165	.029	.3	21	+++
.07	.0465	.1165	80	79	− −
.05	.033	.083	46	71	++
.035	.0225	.0575	14	63	+++
.025	.0165	.0415	3	21	+++
.0175	.012	.0295	.3	8	+++

calculations must therefore be made on the basis of a two-point curve for toxicity of pyrethrum. If these curves can be used, the results (Table 3) show that two of the three dosage series show strong evidence of synergism. If the relationship between nicotine and pyrethrum in table 1 is accepted as a true ratio of toxicity, all series show evidence of synergism. There is some support for this latter interpretation, since 0.1 per cent nicotine killed 67 per cent of the insects, 0.0021 per cent pyrethrum none and the two applied jointly produced 79 per cent mortality.

In the final series of tests, relatively low dosages of nicotine and pyrethrum were applied to insects in lots of 50. A similar lot was injected with both materials. At intervals of 24 hours, mortality was determined and survivors of nicotine treatment were injected with pyrethrum and vice versa. The results (Table 3) show that 0.07 per cent nicotine killed only 28 per cent of the insects in one week, and from 12 to 18 per cent within the first four days. When pyrethrum (0.0086 per cent) was injected 24 hours after nicotine, the total mortality of 90 per cent was approximately the same as the 94 per

Table 3.—Nicotine—Pyrethrum synergism. Milkweed bugs injected with low dose of one followed by the other at intervals of 24 hours.

Number Injected	Date Injected	Number Killed: Nicotine	Number Killed: Pyrethrum	Total	Total Per Cent Killed
50 bugs injected with .07% Nicotine 7/10/50					
Survivors injected with .0086% pyrethrum					
44	7/11	6	39	45	90
43	7/12	7	30	37	74
41	7/13	9	32	41	82
42	7/14	8	28	36	72
Nicotine only		14			28
7/10 .07% nicotine and .0086% pyrethrum				47	94
50 bugs injected with .0086% pyrethrum 7/10/50					
Survivors injected with .07% nicotine					
28	7/11	14	22	36	72
20	7/12	2	30	32	64
17	7/13	1	33	34	68
17	7/14	3	33	36	72
Pyrethrum only			35		70
7/10 .0086% pyrethrum and .07% nicotine				47	94

following joint application of the two materials. Total mortality tended to decline as the time interval between injections was increased.

Nicotine following injection by pyrethrum was not as effective as the two materials applied together.

These preliminary tests indicate that nicotine and pyrethrum are synergistic when injected into milkweed bugs, and that nicotine "conditions" the insects for a higher mortality from pyrethrum.

Literature Cited

Wadley, F. M., 1945. The evidence required to show synergistic action of insecticides and a short-cut analysis. U.S.D.A. Bur. Ent. & Pl. Quar. E.T. **223.**

Sodium Fluosilicate as an Activator for Certain Organic Insecticides and Herbicides

S. Marcovitch, *Agricultural Experiment Station Knoxville, Tenn.*

The insecticidal properties of the dinitrophenols are now well established. They are also used as selective herbicides, and pre-emergence sprays. As a group they are oil soluble. Dinitro-o-cyclohexyl phenol incorporated in dormant oil sprays was used by Kagy and Richardson for the control of the San Jose scale and apple aphids.

The above compound, being highly insoluble in water and difficult to disperse, had to be used as an oil solution. In order to overcome the necessity for the use of oil, water soluble dinitrophenols were developed such as sodium dinitro-ortho-cresylate and the triethanolamine salt of dinitro-o-sec-butyl phenol.

Since these are all different compounds dispersed in different media, it becomes of importance to evaluate their toxicities and performance on different insects and plants.

Literature.—In 1926, Gimingham, *et al.* reported on the toxicity of 3:5-dinitro-o-cresol and other compounds to insect eggs and found that the water soluble sodium salt of dinitro-o-cresol is only slightly less toxic than dinitro-o-cresol in the uncombined state. In tests with dormant sprays on apple Hough found that it required 9.5 ounces of dinitro-o-cyclohexylphenol as a water suspension per hundred gallons for control of apple aphids, and 2.5–2.9 pounds of sodium dinitro-o-cresylate.

Boyce *et al.* in their studies with dinitro-o-cyclohexylphenol found that "From pH 6.0 to pH 9.0 there is a decided reduction in toxicity" to eggs of the plant bug *Lygaeus kalmii*. At pH of 3.25, 78 per cent control was obtained while at a pH of 10.90 only 35.7. In order to take advantage of the increased toxicity in the acid range Boyce *et al.* added oxalic acid at a concentration of three to five ounces per 100 gallons. The acidified oil-nitro-phenol spray emulsions also proved strikingly more toxic to the foliage of citrus trees. However, they suggest that further studies should be made with acidified solutions as applied to dormant sprays where phytocidal action is not such a serious consideration.

In the work on the activation of substituted phenol herbicides, Crafts & Reiber found a greatly increased effect of (sodium dinitro-o-cresylate[1] used as a herbicide when acidified with either ammonium sulfate or sodium bisulfate. The practice of adding either one or both of these relatively non-toxic salts to the dinitro compound, is now accepted by the trade. According to Crafts & Reiber the activation of this compound is the effect of the free acid.

Experimental.—Since various workers have found that substituted phenols acidified with either oxalic acid, ammonium sulfate or sodium bisulfate are more potent, it was thought advisable to try out

[1] *Sinox.*

another acid salt, namely, sodium fluosilicate. Laboratory studies were initiated with mosquito larvae as a test organism and the results are presented in table 1.

Table 1.—**Tests with sodium fluosilicate as an activator for certain organic insecticides using *Culex quinquefasciatus* as test organism and crabgrass for foliage tests.**

MATERIAL	CONCENTRATION	PER CENT KILLED	TIME	FOLIAGE INJURY
1. DN compound[1]	1–1000	80	24 hrs.	Slight
2. DN compound[1] plus Na_2SiF_6	1–1000 1–4000	100	13 min.	Severe
3. Na_2SiF_6	1–4000	80	6 hrs.	Slight
4. SPCP[2]	1–4000	100	4 hrs.	Slight
5. SPCP plus Na_2SiF_6	1–4000 1–16,000	100	8 min.	Severe
6. T.C.A.[3]	1–1000	0	24 hrs.	None
7. T.C.A. plus Na_2SiF_6	1–1000 1–4000	100	24 hrs.	Moderate
8. The dinitro compound[4]	1–1000	100	7 hrs.	Slight
9. The dinitro Compounds[4] plus Na_2SiF_6	1–1000 1–4000	100	12 min.	Severe
10. The dinitro compound[4] plus $(NH_4)_2SO_4$	1–1000 1–1000	100	90 min.	
11. DNOC[5] (in distilled water	1–3000	100	30 min.	
12. DNOC (in tap water)	1–3000	0	96 hrs.	

[1] Triethanolamine salt of dinitro-o-sec butyl phenol (DN-289).
[2] Sodium pentachlorophenate.
[3] Sodium trichloroacetate
[4] Sodium dinitro-ortho-cresylate (*Sinox*).
[5] Dinitro-ortho-cresol.

Sodium pentachlorophenate in a concentration of 1 to 1,000 produced a kill of 80 per cent in 24 hours, whereas the addition of sodium fluosilicate 1 to 4,000 showed 100 per cent mortality in 13 minutes. Equally striking increases in mortality were produced when sodium fluosilicate was added to sodium pentachlorophenate, sodium trichloroacetate, and sodium dinitro-ortho-cresylate. A change in pH can produce most unusual results. For example, 50 mg. of dinitro-ortho-cresol was added to 200 cc. of distilled water with a pH of 6.8. This 1 to 4,000 solution produced 100 per cent mortality in 30 minutes, whereas the same concentration in tap water with a pH of 7.4 was non-toxic even after 6 days.

Using harlequin bug as a test organism, a 1 to 3,000 solution of the sodium pentachlorophenate acidified with sodium fluosilicate produced a kill in 3 minutes when they were immersed for 3 minutes. The pentachlorophenate alone was non-toxic.

Equally striking results were produced when these materials were tested as herbicides on crabgrass and other types of foliage. In all cases the addition of sodium fluosilicate produced much more burning. A sodium pentachlorophenate is now being introduced as a pre-emergence spray in the control of weeds. A small scale test with the sodium pentachlorophenate[1] and sodium fluosilicate when used as a pre-emergence spray gave good control of weeds even when used at one-third the recommended dilution. The resulting precipitate should have an advantage in case of heavy rains that would tend to leach out the more soluble forms. The same should be true when these materials are used in dormant spraying.

The tests on scale insects, the euonymous scale was used since it was readily available. Those used were heavily encrusted on the stems and leaves. A solution of the dinitro compound 1 to 400 gave approximately 40 per cent control under laboratory conditions. Dinitro compound 1–400 plus sodium fluosilicate showed 85 per cent control. It was observed that these scales were difficult to wet. When used with a wetting agent such as sodium alkyl aryl sulfonate at the rate of 0.25 to 0.5 per cent, the combination of the dinitro compound and sodium fluosilicate gave 100 per cent control.

Plans are under way to carry out field tests on San Jose scale and over-wintering aphid eggs with this compound. The greatly increased toxicity produced by acidification with sodium fluosilicate may make it possible to get good results with one-half or even less than the usual recommended dosages.

Sodium fluosilicate has the advantage of being readily available, easy to handle, and very economical in price. A 1 to 150 solution of sodium fluosilicate is in itself an excellent crabgrass killer.

SUMMARY.—Tests were carried out with sodium fluosilicate as an acidulating agent with certain water soluble organics such as the triethanolamine salt of dinitro-o-sec-butylphenol, sodium pentachlorophenate, sodium dinitro-ortho-cresylate and sodium trichloroacetate. In all cases striking increases in toxicity were produced by the production of the parent compound as a free water insoluble organic acid due to the change in pH. The greater toxicity of the free acid should make it possible to get good results with one-half to one-fourth of the dosage used in water solution when applied as a dormant insecticide or as a herbicide or fungicide when treating fence posts.

Aminophenols as Antioxidants[1] for Pyrethrum

GAINES W. EDDY, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Ground pyrethrum and concentrated extracts of pyrethrum are known to decompose in storage, with consequent loss of toxicity to insects. This decomposition is greatly accelerated when these materials are exposed to air, sunlight, ultraviolet light, or high temperatures. The incorporation of antioxidants[1] such as hydroquinone, tannic acid, and resorcinol was shown by Tattersfield and Martin (1934) to retard such decomposition. Gnadinger *et al.* (1935) showed that these and several related materials retard the decomposition of pyrethrum in decalin solution when stored at 35° C. Bushland *et al.* (1945) tested several materials as antioxidants for pyrethrum and found hydroquinone to be the most effective. Attempts to develop antioxidants that would prevent decomposition of the pyrethrins when sprayed on foliage have so far not been very successful.

[1] The term "antioxidant" in this paper is used in a broad sense to include materials having antipolymerization properties, since it is likely that polymerization is one of the chief causes of deterioration of pyrethrum.

Table 1.—Knock-down and mortality of stable flies placed in cages treated from 1 to 21 days previously with an acetone solution containing pyrethrum plus an aminophenol of piperonyl butoxide.

Materials and Concentration (Figures in Per Cent)	1 Day		3 Days		8 Days		14 Days		21 Days
	Minutes for Complete Knock-down	Per Cent Mortality After 24 Hours	Minutes for Complete Knock-down	Per Cent Mortality After 24 Hours	Minutes for Complete Knock-down	Per Cent Mortality After 24 Hours	Minutes for Complete Knock-down	Per Cent Mortality After 24 Hours	Per Cent Mortality After 24 Hours
Pyrethrins 0.05:									
Alone	10	100	—	15	—	—	—	—	—
Plus *o*-aminophenol									
0.5	4	100	10	100	18	100	36	100	95
.25	4	100	14	100	177	100	—	100	50
.05	9	100	—	100	—	50	—	—	—
Plus *m*-aminophenol									
0.5	8	100	51	100	—	40	—	—	—
.25	6	100	28	100	—	25	—	—	—
.05	5	100	—	100	—	5	—	—	—
Plus *p*-aminophenol									
0.5	3	100	6	100	32	100	25	100	100
.25	4	100	6	100	23	100	42	100	80
.05	5	100	10	100	291	100	—	100	20
Piperonyl butoxide									
0.5	6	100	20	100	—	20	—	—	—
.25	6	100	26	100	—	40	—	—	—
.05	7	100	62	100	—	15	—	—	—
Check (untreated)	—	15	—	5	—	5	—	0	10

In May 1949 tests were conducted at Kerrville, Texas, to determine whether the aminophenols prolong the toxicity of pyrethrum residues to stable flies *Stomoxys calcitrans* (L.).

Materials and Methods.—Pyrethrum was tested at a pyrethrins concentration of 0.05 per cent in acetone, alone and in combination with 0.5, 0.25, and 0.05 per cent of *o*-, *m*-, or *p*-aminophenol, and also a synergist, piperonyl butoxide, for comparative purposes.

Cages of 14-mesh copper-wire screen, 3.5 inches in diameter and 8 inches high, were dipped in these solutions, and allowed to stand at room temperature. At intervals of 1 to 21 days thereafter 20 stable flies from the laboratory colony were placed in each cage and the knock-down and kill of the flies over a 24-hour period were noted. These tests were made at 80° ±2° F.

Results.—The results of typical tests are shown in table 1.

All the materials caused rapid knock-down and 100 per cent mortality of the flies exposed after 1 day. After 3 days knock-down was slower, especially with the lower concentrations of the *o*- and *m*-aminophenols. At this time all the mixtures again caused 100 per cent mortality in 24 hours, but the toxicity of pyrethrum alone was greatly reduced. After 8 days mixtures containing *m*-aminophenol and piperonyl butoxide caused incomplete knock-down and no more than 40 per cent mortality, but those containing all three concentrations of *p*-aminophenol and the two highest concentrations of *o*-aminophenol caused 100 per cent mortality. The last two mixtures also killed all the flies after 14 days. After 21 days only the mixture containing the highest concentration of *p*-aminophenol caused 100 per cent mortality, but the comparable mixture containing *o*-aminophenol killed 95 per cent of the flies.

No appreciable mortality of flies was caused by any of the aminophenols alone even as fresh treatments at 0.5 per cent concentration.

The tests described in this paper indicate that the toxicity of pyrethrum to stable flies is prolonged more by *o*- and *p*-aminophenol than by either *m*-aminophenol or piperonyl butoxide. The possibility of stabilizing pyrethrum residues by the use of antioxidants rather than materials that act strictly as synergists is also evident.

Field Tests.—A limited number of field tests conducted against stable flies and horn flies, *Siphona irritans* (L.), showed the *p*- and *o*-aminophenols to be effective extenders of pyrethrum when used under practical conditions.

Toxicology.—The aminophenols are known to be photosensitizing agents. There are reports that some of them have produced skin reactions, particularly on repeated use. R. D. Radeleff (unpublished data) found that unpigmented areas, such as white noses, of Holstein calves treated with relatively high concentrations of *o*- and *p*-aminophenol became badly sunburned. Because of their uncertain toxicological status the aminophenols cannot yet be considered for other than experimental purposes.

LITERATURE CITED

Bushland, R. C., M. S. Schechter, H. A. Jones, and E. F. Knipling. 1945. Antioxidants for pyrethrum powders. Soap and Sanit. Chem. **21**(11): 119–20.

Gnadinger, C. B., C. S. Corl, and C. A. Clark. 1935. Effects of antioxidants on highly concentrated pyrethrum extracts. Soap and Sanit. Chem. **11**(10): 95–99.

Tattersfield, F., and **J. T. Martin.** 1934. Loss of activity of pyrethrum. Jour. Agr. Sci. **24**: 598–626.

The 1950 Greenbug Outbreak in Oklahoma

F. A. FENTON[1] and R. G. DAHMS[2]

INTRODUCTION.—Some years ago the senior author made the statement, based upon a study of departmental records, that there was an outbreak of greenbugs in Oklahoma once every 4 years. The area involved ranged all the way from a few counties to a major part of the wheat belt. The 1950 outbreak was without doubt the most serious on record. It also differed from all other previous outbreaks in that wheat farmers had an insecticide which proved very effective against this species. Moreover, they were in good financial condition to afford the extra expense required and had the equipment, or access to equipment, for applying the insecticide. Because of the widespread interest in weed control, there were many low-volume-crop sprayers available. To an even greater extent, custom spraying service by plane was also available. There were 138 planes from 56 companies and 44 ground units that were licensed by the state entomologist for applying parathion to wheat. Thus, the stage was set for an attack on the pest by the use of the most approved materials and equipment available.

WEATHER CONDITIONS WERE FAVORABLE.—As early as the preceding November, all signs pointed to a possible outbreak. Field surveys showed that the pest was uniformly present in the wheat fields and was causing some damage. The summer had been favorable in that temperatures were below normal and the rainfall, although also below normal, was fairly well distributed. These conditions favored the survival of the greenbugs on volunteer grain. September was cool and wet, the precipitation being 123 per cent of the normal. October and November were dry. In general, the winter months were drier than usual and in some parts of the state drouth conditions began to prevail. Such winter conditions were, in general, also favorable for the greenbug. The outbreak reached its peak in March and April. During these months, the weather remained too cool for parasite activity and yet the the temperatures were high enough to be favorable for rapid development of the greenbug. Drouth conditions also retarded plant growth, further handicapping small grains.

PARATHION FOUND TO BE EFFECTIVE.—Tests made by the junior author in May and November showed that parathion and a commercial preparation containing parathion and the dimethyl analogue of parathion were effective. At the time when it became necessary for farmers to start applications, the only form of parathion which could be used was the wettable powder. This proved to be very abrasive to gear pumps, causing them to wear out even when applied at the rate of 10 to 15 gallons per acre. One customs outfit had to replace all of the pumps on its planes at the end of the first day of operation. Unfavorable publicity made many operators afraid to use the emulsion form when it was released for use by the insecticide division of the Production Marketing Administration. It did not become readily available until about the middle of March. With experience gained in the use of the emulsions, prejudice was overcome and this material was the most commonly used form.

PUBLICITY.—Considerable time was spent at the annual meeting of aerial applicators held in Stillwater in February on greenbug control with parathion. As the attendance at this meeting was well over one hundred and as the men came from most of the central and southwestern states, they gained valuable information that was used to good advantage not only in Oklahoma but in other states infested later in the spring.

The U. S. Bureau of Entomology and Plant Quarantine and the Oklahoma Experiment Station issued a mimeographed circular giving in some detail the methods for using parathion and the precautions necessary for safety to the operator. This was made immediately available to the above meeting and was widely distributed in the state. When it became evident that large amounts of parathion would be used in Oklahoma, the State Public Health Officer was given the method of using atropine so that he could advise county health officers as to this treatment for parathion poisoning. County agents and vocational agriculture teachers were kept informed. The radio and press was utilized to the fullest extent.

Weekly staff meetings were held at the college where plans for the forthcoming week were made. These meetings were attended by extension service and experiment station personnel. Four extension entomologists were in the field working with farmers, county agents and others interested in control. Two of these men were state officials and two were employed by the U. S. Bureau of Entomology and Plant Quarantine. The experiment station staff continued field tests with insecticides and equipment. Temporary headquarters were set up in the field and an agricultural engineer was detailed to work with our staff to test the effectiveness of a mist blower.

LOSSES.—Drouth, greenbugs and brown mites all caused damage to the wheat crop. However, unquestionably, the greatest amount of damage was the total destruction of thousands of acres of wheat by greenbugs. K. D. Blood, agricultural statistician for Oklahoma, estimates that 21.8 per cent of the wheat acreage was abandoned in 1950 compared with 9.2 per cent for the preceding 10-year average. This amounted to 1,271,000 acres. The average yield dropped from 13.8 bushels to 8.5 bushels per acre. Comparative figures for oats were 212,000 acres abandoned or 18.5 per cent compared to 10.3 per cent for the 10-year period. An average of 17.5 bushels were harvested per acre compared to an average of 19.8 bushels for the preceding 10-year period. Acreage planted to barley was comparatively small but 101,000 acres were harvested out

[1] Head Dept. Entomology, Oklahoma A. and M. college Stillwater.

[2] Associate Professor of Entomology, Oklahoma A. and M. College and Entomologist, Bureau of Entomology and Plant Quarantine, U. S. Dept. Agriculture.

of 160,000 acres planted, or 36.9 per cent abandonment. This compared with 17.1 per cent abandonment for the previous 10-year period. The average yield was 11 bushels per acre compared to 16.2 bushels for the 10-year average.

An estimated 21,877,154 bushels of wheat, 2,000,000 bushels of oats, and 800,000 bushels of barley were lost. At an average price of $2.00 per bushel for wheat, the loss to this crop alone was well over 42 million dollars.

BENEFITS OF CONTROL.—A total of 653,936 acres of wheat were treated with parathion. Undoubtedly many thousands of acres would have been a total loss without treatment. There were also many fields that would have yielded some grain without the treatment which, however, greatly increased the yield. Also, as would be expected in any large scale operation, when applications were made during very unfavorable weather there were some failures. However, a conservative estimate shows that there was an average increase of four bushels of wheat per acre. At $2.00 per bushel, this wheat was worth $5,231,488. It cost the farmers $1,307,872 to apply the insecticides, leaving a net increase of $3,923,616 as a result of the campaign.

Mange and Fly Control with Lindane in a Piggery

HARVEY L. SWEETMAN, LEWIS F. WELLS, JR., ALBERT H. TOCZYDLOWSKI and STEVE MOORE III, *Amherst*

It has been well established that lindane is an effective chemical for control of flies and mange mites. Recent reports of toxicity of lindane to young mammals, notably calves (Radeleff & Bushland 1950), prompted this summary of treatments of young pigs with lindane.

A severe infestation of hog mange developed at the University piggery early in 1950. The herd consisted of 33 pigs about 4.5 months old and 30 hogs from 1 to 4 years old. The most severe infestation was among the pigs, most of which had open sores under the front legs and along the belly and flanks. A considerable loss in weight occurred among the pigs preceding diagnosis of the infestation. Skin scrapings from the animals revealed the presence of mites identified by Dr. F. R. Shaw as *Sarcoptes scabiei*, var. *suis*.

A spray made from wettable powder, containing 0.046 per cent lindane, was applied to the animals on February 13. Twenty-five gallons of spray was used in this application. A second spray containing 0.075 per cent lindane was applied to 19 of the animals having the worst sores 2 weeks later at the request of the herdsman. Skin scrapings did not reveal any mites prior to this treatment.

The improvement of the animals following the first treatment was noticeable in 24 to 48 hours and gains in weight occurred within a week. No symptoms of toxicity from the insecticide were evident at any time. All wounds were healed in 6 to 8 weeks following the first treatment. No signs of reappearance of the mange are evident 6 months after the first application.

A large population of flies, largely house flies, developed about the middle of June. Lindane was applied for control of this early fly population. The insecticide is being vaporized continuously[1] at the rate of 1 gram per 24 hours in 26,000 cubic feet of space. Six sows with pigs 2 to 4 weeks old were exposed during the first month of the test, after which the older pigs were removed. Three litters containing 24 pigs were 2 weeks old when the experiment started. Some doors and windows have been open throughout the test period, but less at night than during daylight hours. After 6 weeks of continuous treatment no detrimental effects of lindane to the pigs have been detected. About this time the pigs were replaced with sheep. The lindane application was continued. After the vaporizer was installed the fly abundance was quickly reduced and has remained at a low level to date, 2 months later. Although flies developed early in June, this has not been a severe fly period to date.

[1] An electrically heated device of American Aerovap, Inc. for continuous vaporization of lindane and other insecticides was used.

LITERATURE CITED

Radeleff, R. D., and R. C. Bushland. 1950. Acute toxicity of chlorinated insecticides applied to livestock. JOUR. ECON. ENT. **43**: 358–64.

The Relative Attractiveness of New Jersey Light Traps Painted (a) Green and (b) Yellow to Puerto Rican *Culicoides*[3]

CHARLES E. KOHLER[1] and IRVING FOX[2]

In making surveys for various insects, the entomologist is interested in using trapping methods which give a fairly reliable index of the species of insects and their relative abundance. During recent years much effort has been expended in developing attractants and traps for the purpose of determining the abundance of agricultural pests and insects detrimental to health. The present paper discusses an improved trapping method which was developed for the purpose of trapping large numbers of these insects variously known as sandflies, biting midges, punkies and "No-see-ums" of the genus *Culicoides*. Many species of this genus are known to be attracted to light. During the routine operation of light traps for evaluating mosquito control projects in Puerto Rico, the collections were examined for *Culicoides* to determine the distribution and relative abundance of the local species (Fox & Kohler 1950). The present work was the result of an effort to improve the New Jersey light trap so as to obtain greater numbers of both mosquitoes and *Culicoides*.

Different species of insects vary considerably in the degree to which they are attracted to light. Work in the past has indicated that mosquitoes, for instance, seem to prefer the blue and violet range of the spectrum (Headlee 1937). Johnson (1938) found that attractiveness of colors to insects increases as one advances through the visible spectrum from red to violet. In controlling Japanese beetles, it has been reported by several investigators that traps painted yellow were more effective in attractiveness to these beetles than any of the

[1] S. A. Sanitarian (R), Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Ga.
[2] Asst. Professor of Entomology, School of Tropical Medicine, San Juan, Puerto Rico.
[3] Diptera: Ceratopoganidae (Heleidae).

Table 1.—Collections of *Culicoides* spp. for light traps—Amelia, Puerto Rico.

Light (Watts)	Month	No. of Nights	Green Trap: No. of Specimens of *Culicoides*: *C. inamolae*	*C. furens*	*C.l. jamaicensis*	Total	Avg. per trap Night	Yellow Trap: No. of Specimens of *Culicoides*: *C inamolae*	*C. furens*	*l jamaicensis*	Total	Avg. per trap Night
25	May	10	259	112	9	380	38.0	975	410	23	1408	140.8
	June	7	59	15	8	82	11.7	367	125	24	516	73.7
	July	6	10	8	0	18	3.0	33	15	7	55	9.2
	August	3	0	0	0	0	0.0	14	6	10	30	10.0
Totals		26	328	135	17	480	18.5	1389	556	64	2009	77.3
Average per trap night			12.6	5.2	0.7	18.5		53.4	21.4	2.5	77.3	
40	May	6	274	99	10	383	63.8	992	434	44	1470	245.0
	June	4	60	13	2	75	18.8	276	53	10	339	84.8
	July	4	14	2	1	17	4.3	49	55	8	112	28.0
	August	3	0	0	0	0	0.0	32	12	6	50	16.7
	September	15	9	10	8	27	1.8	11	9	7	27	1.8
Totals		32	357	124	21	502	15.7	1360	563	75	1998	62.4
Average per trap night			11.2	3.9	0.7	15.7		42.5+	17.6	2.3	62.4	
60	May	6	69	38	7	114	19.0	310	225	49	584	97.3
	June	8	38	4	7	49	6.1	119	32	23	174	21.8
	July	1	0	0	0	0	0.0	1	4	2	7	7.0
	August	1	0	0	0	0	0.0	6	1	4	11	11.0
Totals		16	107	42	14	163	10.2	436	262	78	776	48.5+
Average per trap night			6.7	2.6	0.9	10.2		27.3	16.4	4.9	48.5+	

numerous other colors tried (Fleming *et al.* 1940; Whittington & Bickley 1941).

The present study was made at Amelia, in the Municipality of Juana Diaz, near Losey Field, Puerto Rico, in an area where DDT residual spraying was the only anti-anopheline measure being carried on. Time was not available to make comparisons with colors other than white and chrome yellow.

METHOD.—A New Jersey type light trap was painted with chrome yellow around the top, and on both the inside and outside of the cone, and then placed 6 feet from a similar trap painted forest green. Both traps were elevated 6 feet from the ground, light bulbs of 3 different intensities were used, and the position of each trap in the pair was reversed from time to time.

RESULTS.—Table 1 indicates the number of the three common species of *Culicoides* taken in two "competing traps" operated for the 74 trap nights during the period of May to September 1949 for which comparative data are available. It was necessary to discard other collections because they became moldy. The data show that the yellow-painted trap took considerably more *Culicoides* than the forest-green trap, and there is some indication that the 40-watt bulb took more than the other wattages tried.

DISCUSSION.—When population densities of *Culicoides* are high, it is evident that the yellow-painted trap is greatly superior in its ability to trap *Culicoides*. As populations drop, the yellow trap is also more sensitive in picking up adult *Culicoides*, but during September the numbers attracted to the trap were so small that the data were no longer statistically reliable.

SUMMARY.—A New Jersey type light trap painted chrome yellow was found to be superior to one painted forest green in sampling *Culicoides* populations. Data from 74 trap nights, during five months comparative running of the usual green colored and chrome yellow traps indicated the superiority of the latter, except during the period when the gnat populations were at their lowest ebb. There was some indication that the 40-watt bulb took greater numbers of this genus.

LITERATURE CITED

Fleming, W. E., E. D. Burgess, and W. W. Maines. 1940. The use of traps against the Japanese beetle. U. S. Dept. Agr. Circ. **594**: 1–11.

Fox, I., and C. E. Kohler, 1950. Distribution and relative abundance of the species of biting midges or *Culicoides* in eastern Puerto Rico as shown by light traps. Puerto Rico Jour. Pub. Health and Trop. Med., **25**(3): 342–9.

Headlee, T. J., 1937. Some facts underlaying the attraction of mosquitoes to sources of radiant energy. JOUR. ECON. ENT. **30**: 309–12.

Johnson, H. A. 1938. Attractivity of light for *Anopheles* mosquitoes. Jour. Tenn. Acad. Sci., Nashville. **12**: 104–6.

Whittington, F. B., and W. E. Bickley. 1941. Observations on Japanese beetle traps. JOUR. ECON. ENT. **34**(2): 219–20.

Alfalfa Seed Production as Influenced by Insecticide and Fertilizer Application[1]

E. H. FISHER and K. C. BERGER[2]

Symptoms of fertilizer deficiency and damage by insects had been observed in many Wisconsin alfalfa fields. In some cases the two were similar. There was difficulty in determining the relative importance of soil fertility, especially a low boron level, and insects in the damage done to alfalfa.

During the period of April 19 to 26, 1947, top

[1] Contribution of the Wisconsin Agricultural Experiment Station, Madison Wis. Published with the permission of the Director.

[2] Associate Professor of Economic Entomology and Professor of Soils, respectively.

Table 1.—Alfalfa seed yields in pounds per acre on three soil types with and without DDT insecticide and borax.

Fertilizer Treatment	Yield of Alfalfa Seed in Pounds Per Acre							
	Fayette Silt Loam (Field 1)		Superior Clay Loam (Field 2)		Superior Clay Loam (Field 3)		Belfontaine Silt Loam (Field 4)	
	Dusted With 5% DDT	Not Dusted	Dusted With 5% DDT	Not Dusted	Dusted With 5% DDT	Not Dusted	Dusted With 5% DDT	Not Dusted
None	20	<10	83	<10	94	<10	120	<10
400 lbs. 0-20-20	36	<10	92	13	77	<10	123	<10
400 lbs. 0-20-20 plus 40 lbs. borax	141	25	121	33	120	13	205	22
Available boron in soil before treatment (lbs. per acre)	0.44		1.80		2.00		1.36	
Parts per million boron in untreated first crop hay (whole top of plant)	11		28		22		22	

dressings of fertilizer were applied to established stands of alfalfa by means of fertilizer drills or endgate spreaders. The fertilizer treatments and check area were plotted in large single parallel strips. The treatments consisted of an unfertilized strip between two 1-acre plots, one top dressed with 400 pounds of 0-20-20 and the other with 400 pounds of 0-20-20 and 40 pounds of borax.

Crosswise of the soil fertility strips, 5 per cent DDT dust was applied once at about 40 pounds per acre. An undusted area was left for comparison. Dusting was done during a late blossom bud stage of the second crop, but some blossoms were present. Dusting dates for the four fields were August 3, 5, 5, and 9 respectively in the order of their listing in table 1. An airplane applied the dust to fields numbers 2 and 3 and a hand-operated rotary crank duster was used in numbers 1 and 4.

Soil analyses were made just previous to the fertilizer applications, and the available boron contents of the various soils are given in table 1. Among the more important insects infesting the alfalfa were *Lygus oblineatus* (Say), *Adelphocoris lineolatus* (Goeze), *A. rapidus* (Say), and *Empoasca fabae* (Harr.).

The first crop of alfalfa was harvested for hay and the second crop left for seed. The seed crop was harvested in September by cutting 3-foot wide parallel swaths with a Jari mower. The alfalfa was then dried and threshed in a small huller. Yield data are given in table 1.

The results show that neither insecticide nor boron alone gave maximum yields of alfalfa seed. As regards soil fertility it is necessary that the lime, phosphate, and potassium level as well as the available boron content be high. Even high fertility levels did not produce seed when large numbers of insects were present.

Yields were consistently increased with insecticide alone or with the application of borax but in every case top yields were not obtained unless both the insecticide and boron treatments were made. Seed yields with both treatments were increased from 40 to 77 per cent over the next highest treatment.

The Toxicity of Certain Organic Insecticides to Different Strains of House Flies[1]

R. S. Robertson, Jr. and J. C. Gaines, *Department of Entomology College Station, Texas*

The investigations herein described had as their purpose the determination of the comparative toxicity of lindane, DDT and chlordane to different populations of house flies, *Musca domestica* L. A secondary objective was the determination of the residual toxicity of DDT when used to control one of these house fly populations. It has been established by Barber and Schmitt (1948), Babers (1949), Barber *et al.* (1948), Lindquist & Wilson (1948), March & Metcalf (1949) and Sternburg *et al.* (1950) that house flies in some localities have developed some degree of DDT-resistance, the result apparently of continuous contact on the part of specific house fly populations with DDT residues.

The term strains used in this article refers to each of the different fly populations. The original stock designated "laboratory strain" was obtained from the Orlando Laboratory of the Bureau of Entomology and Plant Quarantine. This strain of flies had been cultured in the laboratory and protected from all insecticides during the past 8 years. Parent stock of the so-called "campus strain" was collected from the cattle barns on the campus of Texas A & M College. Flies at these barns have been subjected to residues of DDT continuously for a period of 5 years. The strain designated "natural strain" was collected from untreated barns 7 miles from the campus. It was hoped that this strain approximated closely an average house fly population, untreated by insecticides, for this area.

Cultures of the 3 strains were established early in 1950 and maintained in the laboratory throughout the test period. Rearing techniques as suggested by the National Association of Insecticide and Disin-

[1] Technical contribution No. 1398, Texas Agricultural Experiment Station.

Table 1.—The dosage in milligrams per square foot required to kill 50 per cent of the flies.

Treatment	Fly Populations		
	Laboratory Strain	Campus Strain	Natural Strain
Lindane	.44	.04	.48
Chlordane	.15	.05	.19
DDT	1.99	5.39	4.03

fectant Manufacturers were used. To test the comparative toxicities of the different insecticides on glass, quart mason jars with metal tops having glass inserts were used as testing units. These jars were cleaned and rinsed with xylene before treating with the insecticides. The insecticides were applied to the inner surface of the jar by dissolving the desired weight of insecticide in 3 cc of acetone and placing this amount in each jar. The jar top was replaced and shaken in such a manner as to evenly distribute the material over the entire inner surface. Four replicate jars were used for each dosage and 4 jars were left untreated for comparison. Treated jars were set aside for 24 hours before introducing approximately 25 flies. Prior to the transfer of the 4 to 5-day old flies to the treated jars, they were anesthetized with carbon dioxide. The flies remained in the treated jars for a period of 15 minutes, and were then anesthetized and transferred to clean cages for observation. The number of dead and alive was recorded at the end of a 24-hour period. During this period the flies were fed a sugar-bouillon solution. Flies of each strain were tested with 5 dosages of each insecticide.

Abbott's formula was used to calculate the percentage mortality. The data were analyzed by the Bliss (1938) method to determine the dosage-mortality curves.

The dosage-mortality curves for the several insecticides are shown in figure 1. The median lethal dosage for each insecticide is shown in table 1. The MLD's of DDT for the different strains of flies varied. The dosage of DDT to kill 50 per cent of the flies was considerably lower for the laboratory strain than for the campus strain. However, to obtain high mortalities, a greater dosage was required for the

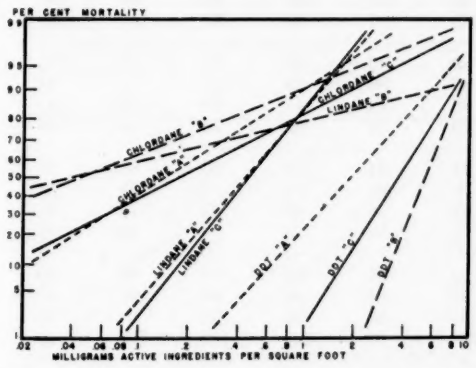


FIG. 1.—Dosage-mortality curves for the toxicity of chlordane, lindane and DDT to (A) laboratory, (B) campus and (C) natural strains of house flies.

Table 2.—Residual tests using 5.43 milligrams of DDT per square foot of surface.

Weeks After Treatment	Per Cent Mortality Following Exposure Periods Indicated	
	15 Minutes	45 Minutes
1	71	
2	60	71
3	31	61
4	21	66
5	60	78
6	57	
7	43	
8	51	
9	51	61
10	45	86

laboratory strain than for the campus strain. All strains of flies were killed with comparatively small dosages of DDT. The campus strain seemed to be more susceptible to chlordane and lindane than the other two strains.

During May, June and July, tests were made to determine the decrease in toxicity of DDT residues. Eight test jars were treated with DDT as described for the comparative tests and 8 were treated with acetone alone to serve as checks. One week after treatment, 4 and 5-day old flies of the natural strain were tested. In 4 of the replicate jars, the flies were exposed for a 15-minute period while they were exposed for a 45-minute period in the other jars. Each week for a period of 10 weeks, this procedure was repeated using the same jars containing the same residues. The jars were stored in the laboratory during the test period. The results of these tests are shown in table 2.

These tests indicated that DDT remained toxic to the natural strain of flies for a period of 10 weeks.

Literature Cited

Babers, F. H. 1949. Development of Insect Resistance to Insecticides. E-776, U.S.D.A Bureau of Entomology and Plant Quarantine.

Barber, G. W., and J. B. Schmitt. 1948. Houseflies resistant to DDT Residual Sprays. N. J. Agr. Expt. Sta. Bul. **742.**

Barber, G. W., O. Starnes and E. B. Starnes. 1948. Resistance of Houseflies to Insecticides. Soap and Sanitary Chemicals **24**(11): 120.

Bliss, C. I. 1938. The Determination of the Dosage-mortality Curve from Small Numbers. Quart. Jour. of Phar. and Pharmacology **11**(2): 192.

Lindquist, A. W., and H. G. Wilson. 1948. Development of a Strain of Houseflies Resistant to DDT. Science **107**: 276.

March, R. B., and R. L. Metcalf. 1949. Laboratory and Field Studies of DDT Resistant Houseflies in Southern California. Calif. Dept. of Agr. **28**(2): 93.

Sternburg, J., C. W. Kearns and W. N. Bruce. 1950. Absorption and Metabolism of DDT by Resistant and Susceptible Houseflies. JOUR. ECON. ENT. **43**(2): 214.

Grasshopper Control[1]

J. C. GAINES and R. L. HANNA, *Texas Agricultural Experiment Station, College Station*

Results of tests conducted at this Station during the period 1947–1949 have been reported in the JOURNAL OF ECONOMIC ENTOMOLOGY. Benzene hexachloride and parathion have proved more effective than either chlordane or toxaphene as contact poisons for grasshoppers, *Melanoplus differentialis* Thos. Benzene hexachloride was found to be more toxic than lindane indicating that isomers other than the gamma contributed to the toxicity of benzene hexachloride. Chlordane and toxaphene are commonly used for grasshopper control because of their long residual stomach action. In general the materials applied as sprays have been more effective than when applied as dusts.

The laboratory and field tests herein reported were conducted near College Station, Texas, during the spring of 1950. The experiments were designed to compare the effectiveness of several new organic insecticides with the materials commonly used. In the laboratory tests, the percentages of mortality were calculated by Abbott's formula while percentages of reduction were used to evaluate the treatments in the field.

LABORATORY TESTS.—These tests were conducted for the purpose of comparing the toxicity of aldrin and dieldrin with toxaphene as contact poisons. Oil miscible concentrates of these materials were applied as emulsion sprays for grasshopper nymph control. Field-collected nymphs were placed in coarse wire cages for spraying. The same techniques as described by Gaines & Dean (1949) were used for these tests in the laboratory. Varying dosages of each material were applied entailing the use of at least 400 individuals, in order to determine each toxicity curve.

Table 1.—The median lethal dose of insecticides as indicated for first and second instar grasshoppers following contact sprays.

TREATMENT	MLD, POUNDS ACTIVE INGREDIENTS PER ACRE
Toxaphene	.91
Chlordane	.49
Parathion	.05
Benzene hexachloride	.04
Aldrin	.04
Dieldrin	.03
Lindane	.08

The toxicity curves shown in figure 1 were calculated by the method described by Bliss (1938). These lines show the comparative toxicity of these materials as contact poisons. Aldrin and dieldrin proved to be equally effective and both materials were more effective than toxaphene.

The median lethal dose for each of several insecticides is shown in table 1. The MLD's for several of the insecticides were determined in 1949 and are included for comparison. Aldrin, dieldrin, parathion and benzene hexachloride proved to have similar contact action.

FIELD TESTS.—These tests were conducted for the purpose of comparing (1) chlordane, (2) toxaphene,

[1] Technical contribution 1399, Texas Agricultural Experiment Station.

Table 2.—Mortality of grasshopper nymphs following spray and dust applications in weed fields.

MATERIAL	METHOD OF APPLICATION	LBS. ACTIVE INGRED. PER ACRE	PER CENT REDUCTION, DAYS AFTER APPLICATION					
			2	5	7	9	12	14
Aldrin	Spray	.14	94	97	97	95	97	95
	Spray	.17	96	94	100	95	98	90
	Spray	.18	94	98	99	98	98	96
	Spray	.18	100	100	100	93	93	85
Dieldrin	Spray	.12	99	100	97	99	99	97
	Spray	.14	100	98	98	97	95	93
	Spray	.15	100	100	100	99	99	99
	Spray	.15	100	100	98	99	100	98
Chlordane	Spray	.84	89	90	88	95	95	85
	Spray	.89	87	86	85	80	87	91
	Spray	.98	83	49	45	48	63	45
	Spray	1.13	73	79	82	73	71	76
Toxaphene	Spray	.95	81	84	85	83	88	84
	Spray	1.14	50	40	64	55	57	66
	Spray	1.20	75	78	80	85	78	80
	Spray	1.36	83	92	88	75	83	85
Toxaphene	Dust	1.0	91	87	87	90	90	84
	Dust	1.0	93	91	92	91	92	87
	Dust	1.4	97	88	88	93	91	88
	Dust	1.5	100	98	100	100	100	95
Compound 1189	Spray	.68	69	81		73	73	
	Spray	1.43	80	84		76	82	

Table 3.—Mortality of grasshopper nymphs following dust applications in weed fields.

Material	Lbs. Active Ingred. per Acre	Per Cent Reduction, Days After Application					
		2	5	7	9	12	14
Aldrin	.30	98	98	98	98	97	97
	.35	100	100	100	99	99	98
	.40	99	98	100	99	99	98
	.45	100	100	99	99	99	98
Dieldrin	.30	100	100	100	100	100	100
	.35	99	100	100	98	100	99
	.35	99	100	99	100	96	96
	.35	100	100	100	100	100	100
Chlordane	1.0	99	99	100	98	97	98
	1.2	98	97	96	98	97	96
	1.2	97	98	99	97	98	100
	2.8	99	99	99	98	98	97
Toxaphene	1.0	99	100	99	99	100	97
	1.0	96	81	97	93	91	88
	2.4	99	99	100	99	100	98
	3.2	98	98	93	100	97	95
Compound 1189	1.2	94	94	98	98	99	97
	1.4	96	95	99	100	99	97
	1.6	92	98	95	97	96	99
	2.2	96	98	99	98	97	96

(3) aldrin, (4) dieldrin and (5) compound 1189[2] for grasshopper nymph control under field conditions. The dust applications were made with rotary hand guns early in the morning while the air was calm and dew present. The sprays were applied later in the day with a compressed air sprayer mounted on wheels. The pressure was maintained by a regulating valve at 40 pounds. Three cone nozzles, 20 inches apart, were attached to the boom allowing complete coverage of the foliage. Moving at the rate of 4.5 miles per hour, this sprayer delivered approximately 5 gallons of spray per acre. The tank was weighed before and after spraying each plat to determine the amount of material applied. In these tests, the poisons acted as both contact and stomach poisons. The plats were arranged in randomized blocks, each 0.05 acre in size subject to nymphs migrating in from untreated portions of the field. The populations were estimated by sweeping each plat with a 16-inch insect net.

The results of these tests are shown in tables 2 and 3. Aldrin and dieldrin sprays applied at the low rate of 2 ounces per acre gave control comparable to that of chlordane and toxaphene at a much higher rate. Aldrin and dieldrin dusts applied at the rate of .3 pound per acre gave complete control and compared favorably with toxaphene, chlordane and compound 1189 at 1 pound per acre. Compound 1189 spray did not prove as effective as the dust. Toxaphene and chlordane dusts gave comparable control with the materials in spray form.

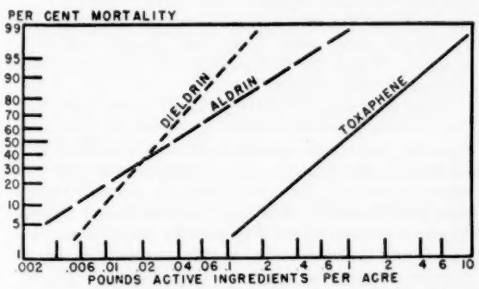


FIG. 1.—Dosage-mortality curves for the toxicity of the insecticides indicated to grasshopper nymphs.

LITERATURE CITED

Bliss, C. I. 1938. The Determination of the Dosage-mortality Curve from Small Numbers. Quart. Jour. of Phar. and Pharmacology. **11**(2): 192.

Gaines, J. C., and H. A. Dean. 1949. Comparison of Sprays and Dusts for Grasshopper Control. JOUR. ECON. ENT. **42**(6): 956.

[2] An oxygenated dimer of hexachlorocyclopentadiene.

Emergency Insect Control in North Dakota[1]

J. A. MUNRO and R. L. POST, *North Dakota Agricultural Experiment Station, Fargo*

Emergency insect control is the title of a recently approved research project in the Department of Agricultural Entomology of the North Dakota Experiment Station. Its object is to provide for investigation of various insect pests, which, because of their unpredictable nature and the need for more effective means of control, must come under this type of classification.

[1] Progress report on Bankhead Jones Offset 94 "Emergency Insect Control."

The need for such a project has also been emphasized of late by the remarkable new insecticides coming into use, especially the chlorinated hydrocarbons and organic phosphates. They are displacing or rendering obsolete many of the old time chemical control measures, and each one must be evaluated. The emergency insect control project does not take the place of the usual specific projects dealing with the biology and control of a single species or closely related group of pests. It is intended only to provide for investigations which, although unforeseen, annually occur in some form or other and require research effort.

Most research agencies probably wish to apportion their research funds according to the needs of the active projects. That is the plan in effect at the North Dakota Agricultural Experiment Station. The time distribution of the investigators as well as the operating budgets are apportioned over the active projects—hence, the necessity of having an emergency project to allow for the time and funds required in the investigation of problems coming in this category.

Among the insects which of necessity come under emergency insect control, aphids seem to hold first place. In fact, it was the problem occasioned by aphids, *Toxoptera graminum*, and their devastation of small grain crops in North Dakota in the spring of 1949 that led to putting the project into operation. However, until the project was approved, the effort put into emergency investigation was done largely at the expense of the already established research projects. The special problem requiring investigation may vary greatly from year to year but even so, our experience has demonstrated that they must be provided for in this special type of project to allow for their investigation.

That aphids hold a prominent place in this type of research is probably due in a large part to the unpredictable factors which govern their abundance. For a pest such as the greenbug the prevailing winds from areas where the aphids are already established and stage of growth of the cereal crops, etc., probably account for their ability to establish themselves in this northern area. In 1949 and again in 1950, these insects occurred in outbreak form in the southern great plains area, but only in the spring of 1949 invaded North Dakota to cause serious loss of crops. They were then successfully controlled by the organic phosphates—tetraethyl pyrophosphate and parathion.[1] That the greenbug failed to become an "emergency" in 1950 in this area is probably due to weather or to other factors which were unfavorable to re-occurrence here.

In addition to the information developed on greenbug control the following has been demonstrated:

Aldrin at 4 oz. technical per acre controlled grasshoppers but did not control black field crickets. Application of Heptachlor at 4 oz. and compound 1189 at 6 oz. per acre resulted in satisfactory cricket control with residual effects lasting up to three weeks. A mixture of chlordane at 8 oz. and toxaphene at 1 lb. technical per acre gave a higher degree of control than either insecticide used alone at double rates for each.

Corn leaf aphid control is practicable. Half of a 20 acre corn field heavily infested with corn leaf aphids was treated with parathion at 24 fl. oz. of 16 per cent emul. conc. per acre by airplane. Yield from both halves of the field taken separately showed 48 bushels of ear corn obtained from the treated while only 40 bushels per acre from the untreated areas. The increased yield value ($8.00) less the cost of application ($2.50) represented a net gain of $5.50 per acre. There has been considerable controversy about the loss caused by corn leaf aphids. This experiment indicates both the amount of loss from a heavy infestation and the dividends from application of aphicides.

Toxaphene at the rate of 2 lbs. actual insecticide per acre gives good control of sugar beet webworms. This rate however, should be increased to 2.5 lbs. per acre later in the season when the plants are large or if the larvae are half to two-thirds grown.

Sulphur continued to give outstanding control of common evergreen mites in comparison with some of the newer acaricides. These tests indicated a very little difference in control with a day or two following their application. Ethyl p-nitrophenyl thiobenzenephosphonate and sulphur had important residual actions 2 weeks following treatment.

As a result of this project it has been possible to conduct a series of control experiments and secure pertinent data on the biology of the pest in question. The information obtained, particularly as it relates to the role of the new insecticides in improved control has been very much worth while. The emergency insect control project is justified both from the standpoint of accounting for expenditures in the work for the investigation of urgent and unforeseen problems in agricultural entomology of this area.

[1] Greenbug Outbreak in 1949, J. A. Munro & E. G. Davis, Bimonthly Bulletin *12* (1): 3–8.

Effect of Abrasive Diluents on the Toxicity of Lindane to the American Cockroach

P. G. PIQUETT and C. V. BOWEN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

The increased toxicity of some mixtures of insecticides with certain diluents has been attributed to a more rapid penetration of the toxicant after abrasion of the insect's surface by the diluent. Wigglesworth (1945) reported that the mortality of *Rhodnius* exposed to alumina and then to a 2 per cent nicotine solution was 100 per cent in 20 minutes, whereas insects treated with the same toxicant without previous exposure to alumina were only slightly affected in 24 hours. When powdered rotenone was substituted for the nicotine, all the alumina-treated insects were dead in 24 hours whereas the unexposed insects were unaffected after 3 weeks. Hunt (1947), who carried out tests on the Mexican bean beetle, *Epilachna varivestis* Muls., using walnut-shell flour and kaolin with cryolite and with rotenone, concluded that "the effect of a diluent on the toxicity of a mixture may arise from two factors following abrasion. These are desiccation and increased penetration of the toxicant."

Lindane was used as the toxicant in an investigation of the abrasive action of diluents. Two very abrasive materials, quartz and carborundum, were selected as the diluents. Dust formulations were prepared by milling the components in a small laboratory pebble mill for 4 hours. The test insect was the American cockroach, *Periplaneta americana* (L.), which was known to be highly susceptible to the gamma isomer of benzene hexachloride (Piquett 1948). The mouth parts were sealed with cellulose acetate to prevent ingestion of the toxicant.

Seven dishes 9 inches in diameter and 3.75 inches deep were prepared for the tests in a series with each diluent as follows: Three dishes contained 2.5 mg. of the diluent only, two a film of lindane (0.05 mg.) obtained by evaporating the solvent from a measured solution of known strength, one 2.5 mg. of dust containing 2 per cent of lindane and 98 per cent of the diluent, and the seventh neither diluent nor lindane.

Fifteen male cockroaches were placed in each dish except the one containing no material and one of those containing the lindane film. After 4 hours the insects in two of the dishes containing the diluent alone were transferred to the two remaining dishes so that one group was not further exposed and the other group was exposed only to the lindane film. At the end of 24 hours mortality counts were made. Ten replicates were made of each test. The results are given in table 1.

Table 1.—Effect of the abrasive diluents carborundum and quartz on the mortality of American cockroaches exposed to lindane. Total exposure 24 hours.

Treatment	Per Cent Mortality	
	Carborundum	Quartz
Diluent alone	10	8
Diluent alone 4 hours, empty dish 20 hours	6	1
Diluent alone 4 hours, lindane film[1] 20 hours	27	11
Lindane film[1]	42	47
Lindane plus diluent (dust)	68	74
Least significant difference (19:1)	20	21

[1] No diluent.

An analysis of variance was made on each series separately because of the use of different populations of roaches. Since many of the tests with diluent alone resulted in no mortality, they were not included in the analysis.

The mortality was higher in the 24-hour exposure to the lindane film than in the 20-hour exposure, the difference being definitely significant in the quartz series. An increase in mortality during the additional exposure period may be expected, since the mortality of roaches held in cages of this type usually progress with time.

The dusts containing lindane and diluent were much more toxic than the same amount of lindane film. This may be explained by the exposure of the insects to the increased surface of the toxicant, due either to more finely divided particles or to the coating of diluent particles. However, exposure of the roaches to either of these diluents prior to placing them in the dishes containing lindane did not increase the mortality.

Literature Cited

Hunt, C. R. 1947. Toxicity of insecticide dust diluents and carriers to larvae of the Mexican bean beetle. Jour. Econ. Ent. **40**: 215–9.

McGovran, E. R., and P. G. Piquett. 1946. Roach powder tests. Soap and Sanit. Chem. **22**(8): 157, 159, 181.

Piquett, P. G. 1948. Benzene hexachloride and cornstarch as a roach control combination. Jour. Econ. Ent. **41**: 326–7.

Wigglesworth, V. B. 1945. Transpiration through the cuticle of insects. Jour. Expt. Biol. **21**: 97–114.

Oviposition by the Two-Striped Grasshopper in a Strip-Farming Area

George T. York,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Oviposition by the two-striped grasshopper, *Melanoplus bivittatus* Say, is generally considered to be in soil along roadsides, field margins, and similar uncultivated areas (Shotwell 1938 and 1941). However Fox (1944) in reporting an unusual egg-laying site for *M. bivittatus*, namely, piles of threshed wheat left in the field owing to lack of storage facilities, also noted that "Unusual concentrations of egg pods of *Melanoplus mexicanus*, as well as *M. bivittatus*, were found in small openings in the crop where grasshoppers were exposed to the sun but protected from the wind."

In outlining experiments on the control of *Melanoplus bivittatus* in an outbreak area in north-central Montana in 1948, it was expected that the problem would be one of control along roadsides and field margins to hold the population to a non-economic level. Such a procedure was found to be impractical, however, because observations made soon after the eggs started to hatch showed that populations of grasshoppers were generally distributed through the fields. This indication that many eggs must have been laid within as well as outside of the fields led to a study of the egg-laying habits of *M. bivittatus* in the area during the ensuing oviposition period.

The area in north-central Montana, like much of the Great Plains region, is now strip-farmed, *i.e.*, alternate strips of crop and fallow within individual fields extend north and south across prevailing westerly winds. These strips vary in width, depending on soil type and wind velocity, but in north-central Montana they are usually about 175 feet wide.

Observations at the start of the oviposition period showed that egg pods were being concentrated in the clumps of standing grain on the outside drill row next to the fallow. Some egg laying was also noted in the fallow near the grain, as well as in the grain strip. Accordingly, observations were made in five zones consisting of (1) the outside foot of the grain strip, (2) the next 10 feet into the grain, (3) the remainder of the grain to the center of the strip, (4) the first 11 feet of fallow, and (5) the remaining portion of the fallow to the center. Square-foot samples were taken in each of 25 places in each zone by shaving away the soil and exposing the pods, as described by Shotwell (1938). Five fields were examined in this way.

The results (Table 1) showed a concentration of egg pods in the outside foot of the grain strip ten times as great as in the adjacent grain zone. The number of egg pods in the remaining portion of the grain strip, as well as in the fallow adjacent to the

[1] The writer acknowledges the supervision and assistance of J. R. Parker, in charge of grasshopper research at Bozeman, Mont., Lee Seaton and F. E. Skoog (resigned May 1949) of the Bozeman, Mont. Laboratory, and temporary field assistants R. S. Woolley, E. J. Hines, and F. D. Mitchell assisted in the routine sampling.

Table 1.—Number of egg pods per square foot in five zones of five strip-farmed fields in north-central Montana in 1948.

Field	Grain Strip			Adjacent Fallow Strip	
	11 Feet to Center	1 to 11 Feet Within	First Foot	Edge to 11 Feet Within	11 Feet to Center
1	0.13	0.17	5.68	0.32	0.03
2	.30	1.13	3.93	1.03	.03
3	[1]	.03	3.68	.03	.03
4	.60	.53	4.63	[1]	[1]
5	[1]	.17	2.57	.13	[1]
Mean	0.34	0.41	4.10	0.38	0.03

[1] No sampling done in this zone.

grain, was comparable to the number in the grain next to the edge. Few eggs were deposited toward the center of the fallow.

If the number of egg pods in each zone is weighted according to the number of feet into the zone involved, a better picture is obtained of the abundance and distribution of egg pods in an entire field (Table 2). Even though the number of pods per square-foot unit in the main portion of the grain strips was low, most of the egg pods present in the field were laid in that portion. In spite of the marked concentration of pods in the edges of the grain strips, only 10 per cent of the total number of eggs were located therein. Over five times as many eggs were laid in the grain strips as in the fallow.

Only miscellaneous sampling was done in roadsides and field margins. The samples indicated that the deposition of egg pods in such locations was comparable to that in the edges of the grain strips, or about four pods per square foot. As the field margins were only 2 to 6 feet in width, their contribution to the total population in fields that usually averaged 160 acres was considered negligible.

The generally accepted theory that egg pods of *Melanoplus bivittatus* are concentrated in margins of the fields is still tenable, but in strip-farmed areas each strip provides extensive lengths of margin. The fallow strips make the environment within the fields favorable to the grasshoppers, which move out onto the fallow for warmth during the day and back into the grain strips for protection or warmth at night (York 1949). Thus, strip-farming provides much more extensive areas favorable to *M. bivittatus* than were reported by Fox (1944) and apparently is more favorable for this species than solid stands of grain in large fields.

In strip-farmed areas where *Melanoplus bivittatus* is present the edges of the strips should be sampled, as well as the main portion of the grain strip and the fallow adjacent to the grain. If sufficient sampling is done to establish the ratios between the numbers of eggs in the different zones, then the sampling of the grain margins only should be a sufficient basis for determining the probable number of egg pods present over a considerable area with a minimum expenditure of time and effort.

Literature Cited

Fox, W. B. 1944. An unusual egg-laying site for the two-striped grasshopper. Can. Ent. **76**: 111.

Shotwell, Robert L. 1938. Some problems of the annual grasshopper survey. Jour. Econ. Ent. **31**(4): 523–33.

Shotwell, Robert L. 1941. Life histories and habits of some grasshoppers of economic importance on the Great Plains. U. S. Dept. Agr. Tech. **Bul.** 774.

York, G. T. 1949. Grasshopper population reduced by gulls. Jour. Econ. Ent. **42**(5): 837–8.

Table 2.—Occurrence of egg pods in different zones of five strip-farmed fields in north-central Montana in 1948.

Zone	Mean Number of Pods per Square Foot	Mean Number of Feet Into Zone	Total Number of Pods	Per Cent of Pods
Grain Strip:				
11 feet to center	0.34	76.5	26.0	63.9
1 to 11 feet within	.41	10.0	4.1	10.1
First foot	4.10	1.0	4.1	10.1
Total	—	87.5	34.2	84.1
Adjacent Fallow Strip:				
Edge to 11 feet within	.38	11.0	4.2	10.3
11 feet to center	.03	76.5	2.3	5.6
Total	—	87.5	6.5	15.9

Influence of Lime and Nitrogenous Fertilizers on the Population of Greenbugs Infesting Oats[1]

F. S. ARANT and CALVIN M. JONES[2]
Alabama Polytechnic Institute, Auburn

Many observations have been made which support the theory that certain crops grown in soils with nutrients optimum for healthy, vigorous plants are resistant to or better capable of withstanding attacks by certain insects than crops grown in nutrient-deficient soils. Investigations by Wittwer & Haseman (1945) showed that the common greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouche), preferred New Zealand spinach grown in soils deficient in nitrogen and calcium. They stated that injury to plants grown in low nitrogen levels was decreased by the addition of lime. Haseman (1946) reported that chinch bugs, *Blissus leucopterus* (Say), matured faster, lived longer, and produced more offspring when nitrogen was withheld from the nutrient solutions in which corn plants were grown as food. He stated that this host preference was observed in nature during the summer when the chinch bugs were numerous. The heaviest infestations were found on corn plants in a weak condition due to low fertility of the soil.

Data presented by Haseman (1946) indicated that the greenbug, *Toxoptera graminum* (Rondani), has a high nitrogen requirement. Greenhouse experiments were conducted at the Agricultural Experiment Station of Alabama Polytechnic Institute, Auburn, to determine the effects of lime and nitrogenous fertilizers on population of the greenbug infesting oats.

METHODS.—Oats of the Victorgrain variety were grown in 2-gallon crocks containing Norfolk sandy soil. The test was of the factorial design containing 3^2 fertilizer treatments replicated four times in each of two greenhouses. The treatments consisted of four rates of nitrogen (0, 40, 80, and 120 pounds of nitrogen per acre), two sources of nitrogen (sodium nitrate and ammonium sulfate), and three methods of application (all under, one-fourth under and three-fourth side-dress, and all side-dress). These treatments were used in unlimed soil (pH 5.65) and in the same type soil to which ground limestone was added at the rate of two tons per acre. Phosphorus and potassium were added to all pots at the rate of 800 pounds of superphosphate and 175 pounds of potassium chloride per acre. The plants in one greenhouse were infested with a known number of greenbugs, and the plants in the other greenhouse were used as a control and were kept free of all insects.

Table 1.—Effects of rates, sources, and methods of applying nitrogen on greenbugs infesting oats (First count, March 16, 1948).

Source of Nitrogen	Method of Application	Nitrogen Rates in Pounds Per Acre			
		0	40	80	120
		Greenbugs Per Leaf			
$(NH_4)_2SO_4$	All under	50.0	17.9	27.3	11.1
$NaNO_3$	$\frac{1}{4}$ under $\frac{3}{4}$ side	39.6	11.4	14.8	12.0
$NaNO_3$	All side	34.4	30.5	13.5	10.9
$NaNO_3$	All under	30.8	11.1	28.2	18.3
	Average	38.7	17.7	21.0	13.1

Table 2.—Effects of lime and nitrogen on greenbugs infesting oats (Second count, April 22, 1948).

Pounds Nitrogen per Acre	Average Greenbugs per Square Centimeter of Leaf		
	Lime	No Lime	Average
0	10.9	19.5	15.2
40	7.0	5.9	6.5
80	2.4	4.1	3.3
120	2.3	2.4	2.4

The oats were planted January 31, 1948. The initial infestation was made March 16 by placing 12 greenbugs on the three plants in each pot. The first population count was made March 31 by counting the total number of greenbugs and leaves per pot; this count was expressed as greenbugs per leaf. The second population count, made April 22, was made by counting the number of greenbugs on the second leaf from the top of each tiller and taking length and width measurements of these leaves. The infestation was expressed as greenbugs per square centimeter of leaf surface. The oats were harvested May 26.

RESULTS.—The results of this experiment are preliminary. The greenbug population varied inversely with the amount of nitrogen applied to the oats.[3] At the time of the first infestation count, the average number of greenbugs per leaf on all oats receiving no nitrogen was 38.7 as compared with 17.7, 21.0, and 13.1 per leaf for the 40-, 80-, and 120-pound rates, respectively (Table 1). The greatest population difference was between treatments which received no nitrogen and treatments which received 40 or more pounds per acre. There were no overall differences which could be attributed to the source or method of applying the nitrogen.

The second greenbug count yielded results similar to the first count (Table 2). As nitrogen rates were increased the number of greenbugs per square centimeter of leaf surface decreased. The average number of greenbugs per square centimeter of leaf on all oats receiving 0, 40, 80, and 120 pounds of nitrogen per acre was 15.2, 6.5, 3.3, and 2.4, respectively. The addition of lime showed the greatest effect in decreasing the population where no nitrogen was used.

Statistical analysis of the two infestation counts showed a highly significant difference between greenbug populations on the plants receiving various amounts of nitrogen. The sources and methods of applying the nitrogen had no significant effect on the populations.

The data on the effects of greenbugs in reducing the yield of grain showed that the average yield

[1] Data presented herein are taken from a thesis presented by Mr. Jones to the graduate faculty of Alabama Polytechnic Institute in partial fulfillment of requirements for the Master of Science Degree.

[2] Credit is due Gerald W. Naylor for assistance on this project, particularly with reference to its agronomic aspects.

[3] In a second experiment in 1949, there was no consistent relationship between aphid populations and fertilizer treatments. However, warm weather was unfavorable for development of the aphid and was very favorable for parasitic species. Parasitism became the determining factor in greenbug abundance.

of grain per pot was lowered by the infestations. The extent of the reduction was difficult to correlate with the addition of lime or the amount of nitrogen applied because of the variable differences in yields.

SUMMARY.—Greenhouse tests were made to determine the effects of lime and nitrogenous fertilizers on the population of greenbug, *Toxoptera graminum* (Rondani), infesting oats. Nitrogen from two sources applied three different ways at the rate of 0, 40, 80, and 120 pounds per acre was applied to Victorgrain oats grown in unlimed and limed Norfolk sandy soil. The plants were infested with a known number of greenbugs. Infestation counts showed that as the rates of nitrogen were increased the population of greenbugs per unit of leaf surface decreased. The addition of lime also decreased the population of greenbugs, and the decrease was greatest where no nitrogen was used. The source and methods of applying the nitrogen had no significant effect on the populations.

LITERATURE CITED

Haseman, Leonard. 1946. *Influence of Soil Minerals on Insects.* JOUR. ECON. ENT. 39(1): 8–11.

Wittwer, S. H., and Haseman, L. 1945. *Soil Nitrogen and Thrips Injury on Spinach.* JOUR. ECON. ENT. 38(5): 615–6.

A Field Test of Some Organic Insecticides for Control of the Armyworm

E. T. HIBBS and C. R. WEAVER, *Ohio Agricultural Experiment Station, Wooster*

An outbreak of the armyworm, *Cirphis unipuncta* (Haw.), in Ohio in June, 1950, was utilized to field test some relatively new organic insecticides in the control of the insect.

Typical of armyworm outbreaks in Ohio, the infestation presented a pattern across the state of scattered foci of intense infestations wherein young corn plants were stripped of leaves, wheat heads and leaves were partially eaten, and grasses, especially timothy, were severely damaged by the feeding of the larvae. Also typical of armyworm infestations, they were rarely discovered before damage to the crop was extensive. Under these conditions arsenical baits are not always adequate.

There have been few reports in the literature of the efficacy of the recently developed organic insecticides in the control of the armyworm. Packard (1946) reported that 2 and 10 per cent dusts of DDT in pyrophyllite, and a spray containing 2 pounds of DDT (water dispersible powder) per 100 gallons of water were not effective against larvae infesting tall, headed-out rye. Bottger & Levin (1946) reported that, in their laboratory tests, dusts of benzene hexachloride (pure gamma isomer with fullers earth) were more effective than DDT at even higher concentrations against nearly fullgrown larvae. Smith & Caldwell (1947) reported that sprays of 0.1 per cent DDT killed many larvae and caused a sharp decline of damage in the field.

The first test carried out at Wooster, Ohio, in 1950 included DDT, toxaphene, and chlordane applied June 23 between 2 P.M. and 4 P.M. to 0.125 acre field-corn plots in three-fold replication randomly arranged in blocks. The plants, 12 to 18 inches high and in the whorl stage, were naturally infested with armyworm larvae. Each insecticide was applied at one pound of the active ingredient per acre at 30 pounds pressure with a low volume sprayer delivering 37 gallons of spray material per acre.

The evaluation of the treatments was based upon counts of living larvae observed, with the aid of a flashlight, upon 200 plants per plot on June 26 between midnight and 4 A.M. when the larvae were actively feeding.

Table 1.—Mean number of living larvae per 200 plants 60 hours after treatment.

TREATMENT	MEAN NUMBER LARVAE
Toxaphene	3.0
DDT	5.3
Chlordane	13.0
Check	26.3

Least significant difference at 5 per cent = 7.2.

A second test involved sprays of parathion, toxaphene, DDT, chlordane and lindane applied with a 3-gallon compressed air sprayer to five replicates of single-hill plots each containing four plants of field corn 18 inches high and in the whorl stage. Parathion and lindane were used at 0.5 pound of toxicant per 100 gallons; other materials at 1 pound of toxicant per 100 gallons of water.

Ten field collected full grown larvae were placed on or near the plants of each hill and confined there with a screen cage. Three days later living and dead larvae were recovered from the cages and the damage to the corn was evaluated.

Table 2.—Per cent control of armyworm larvae after being caged 72 hours with treated field corn plants.

TREATMENT	PER CENT LIVING	PER CENT CONTROL[1]
Parathion	2.3	96.4
Toxaphene	19.6	69.0
Chlordane	23.8	62.4
DDT	30.8	51.3
Lindane	63.3	5.1
Check	66.7	—

[1] Computed by Abbott's formula.

In descending order of effectiveness in stopping larval feeding the materials were: parathion, toxaphene, DDT, chlordane, and lindane. Almost no feeding occurred in the parathion treated plots, whereas feeding in lindane treated plots equalled that in the check plots.

LITERATURE CITED

Bottger, G. T., and C. Levin. 1946. Comparative toxicity to insects of benzene hexachloride and DDT. JOUR. ECON. ENT. 39: 539–41.

Packard, C. M. 1946. DDT dusts and sprays, and bran baits containing different poisons, for armyworm control. JOUR. ECON. ENT. 39: 669.

Smith, J. H., and N. E. H. Caldwell. 1947. Armyworm and other noctuid outbreaks during 1946–47. Qd. Agric. Jour. 65: 396–401.

Comstock Mealybug in Ohio

C. R. CUTRIGHT, *Wooster, Ohio*

Comstock's mealybug is known to have been present in Ohio for almost 30 years. It was first taken feeding on the umbrella catalpa and later on the Japanese honeysuckle. Other Ohio hosts are damson plum and peach, though there is only one collection record for each.

Its occurrence on apple was not discovered until 1939 when it was found in the Cecil McCown orchard at Proctorville, Ohio. This orchard is located on the valley floor of the Ohio River, only a short distance across and up the river from Huntington, West Virginia. Other orchards to be mentioned later are all located in this general area.

At the time of discovery a very heavy infestation had already developed, principally on the Grimes Golden variety. Approximately 80 per cent of all fruits of this variety were partially or wholly covered with a black fungus that was growing on the honeydew dropped by the mealybugs on fruits and foliage. In view of the severity of the infestation, mealybugs must have been present in the orchard at least during 1938. The origin of the infestation is unknown though it is possible that it might have come from Japanese honeysuckle that is found around the orchard and from which the mealybug was also collected.

The injury to the fruits is due almost entirely to the growth of the fungus upon them. This fungus is very adhesive and difficult to remove. Even modern washing equipment will remove only a portion from the surface of the apple while that growing in the calyx and in the stem end of the fruit is not disturbed. As the fungus grows older it hardens to almost the consistency of dried varnish, under which different fruit rots frequently develop.

As this paper deals with control by parasitism no discussion of the experimental chemical control program will be presented. However, it should be said that attempts at chemical control were failures, due either to ineffectiveness or to the economics involved. Chemical controls were attempted in 1939 and 1940 but were abandoned after that time. Mechanical controls, consisting of scraping loose bark from the trees and of passing blow torch flames over the trunks and larger branches, were also used by one grower but were discontinued after 1940.

With the failure of chemical and mechanical methods, biological controls were undertaken and the Bureau of Entomology and Plant Quarantine was contacted and arrangements made for securing parasites. All parasites that have been released in infested orchards have originated in the laboratory of the Bureau of Entomology and Plant Quarantine at Charlottesville, Virginia.[1]

The first lot of parasites consisting of 3,400 *Clausenia* sp. was released on July 24, 1940. On August 8, an indeterminate number of *Allotropa* sp. was released. Both *Clausenia* and *Allotropa* were placed in the Grimes Golden block of the McGown orchard where the infestation was most severe. Collections of adult female mealybugs made on August 21 of 1941 and sent to the laboratory at Charlottesville for parasite rearing produced 3 per cent of parasitized individuals. Both *Allotropa* and *Clausenia* were recovered. The parasites of these species released in 1940, therefore, had established themselves and had overwintered successfully.

The growing season of 1941 started with low mealybug populations but these rapidly increased and by mid-August severe injury had occurred. On August 21 liberations of *Leptomastix* sp., *Pseudophycus* sp., and *Clausenia purpurea* were made. This was followed on August 29 by further releases of *Pseudaphycus* and on September 16 and 17 by additional numbers of *Allotropa*, *Pseudophycus* and *Clausenia*. This last group was distributed almost equally between the McCown and the Quaker bottom orchards where infestation by the mealybug was first noted in 1940. The total number of parasites liberated in 1941 is thought to have been in excess of 20,000 individuals.

In October 1941, collections of full grown female were made and parasites reared from them at Charlottesville. Recoveries of all the liberated species were obtained but only in very small numbers. Those parasitized amounted to 2 per cent or just about the same as that carried over from 1940. Fruits injured by black fungus ran about 35 per cent or somewhat higher than in 1940.

In 1942, releases of parasites were made on June 1 and July 24. On both occasions parasitized "mummies" were equally divided between the McCown, Quaker bottom, and Watson No. 1 orchards. The Watson No. 1 orchard was found infested with mealybugs in the autumn of 1941.

Rearings in the Charlottesville laboratory showed 2.9 per cent, 15 per cent and 91.9 per cent parasitized from the first, second, and third generations respectively. *Allotropa* and *Pseudophycus* were the only species involved in the first and second generation recoveries and they were by far the dominant species in the third generation when a few *Clausenia* also appeared. The increase in parasitism was outstanding and gave promise of control for the following year. Injury due to the black fungus was very severe in 1942, and was found on about 85 per cent of all fruits.

The year 1942 also marked the first appearance of the entomogenous fungus which killed 8.9 per cent of the non-parasitized mealybugs of the second generation and 17.4 per cent of the third.

Following the heavy parasitism in 1942, the developments in 1943 were followed with great interest. There were no liberations of parasites during this season. In late June, mealybugs were very hard to find except in the Watson No. 2 orchard where a heavy infestation was first noted in 1942. Collections made at this time showed 11 per cent of all first generation adults parasitized. In August, mealybugs were very scarce (except in the Watson No. 2 orchard) but 95.7 per cent of those collected were parasitized. The fruit was only about 0.1 per cent injured in the McCown orchard, less than 2 per cent in the Quaker bottom, and none in the Watson No. 1. However, in the Watson No. 2 orchard 100 per cent injury occurred.

In 1944–45–46–47 and 1948 there was no commercial injury from mealybugs in any of the orchards where parasites had been liberated. This includes the Watson No. 2 orchard which was almost one-half mile distant from Watson No. 1. Natural spread of parasites had effectively controlled the mealybug in this block. The per cent parasitism in the different years for the area as a whole has been: 1944—14.7 per cent; 1945—4.7 per cent; 1946—2.0 per cent (second generation), 3.6 per cent (third generation); 1947—13.6 per cent

[1] Special thanks are due Dr. B. A. Porter, Dr. G. J. Haeussler and Dr. D. W. Clancy for their close cooperation. Without their aid, little of this work would have been possible.

Table 1.—Status of Comstock's mealybug in one Ohio orchard (McCown) 1939–1948 inclusive.

YEAR	POPULATION STATUS	PER CENT OF FRUIT INJURED	PER CENT OF NON-PARASITIZED MEALYBUGS KILLED BY FUNGUS	PER CENT PARASITISM
1939	Very heavy infestation	80	0	0
1940	Heavy infestation	30	0	T
1941	Heavy infestation	35	1st gen. —[3]	—[3]
			2nd gen. 0	3.0
			3rd gen. 0	2.4
1942	Very heavy infestation	85	0	2.9
			8.9	15.0
			17.4	91.8
1943	Very light infestation	T[1]	85.7	33.3
			92.6	97.3
			—[3]	—[3]
1944	Very light infestation	T	—	—
			0	0
			—	—
1945	Low infestation	T	—	—
			11.8	4.7
			—	—
1946	Low infestation	T	—	—
			3.5	1.2
			2.0	5.1
1947	Very low infestation	0	—	—
			8.0	24.0
			—	68.0
1948	Very low infestation	0	—	—
			0[2]	0[2]
			—	—

[1] Indicates less than 0.5 per cent.
[2] Heavy spray schedule of DDT used for the first time.
[3] Indicates no record for this generation.

(second generation), 64.5 per cent (third generation); 1948—1 per cent.

Factors other than parasitization have also aided in this record of control. Since 1942, when it was first found, the entomogenous fungus has been present in the orchards and at times has been quite effective. This was especially true in 1943 in certain blocks of the McCown orchard (see Table 1).

In 1946, 1947, and 1948 the Quaker bottom and Watson orchards used DDT against the codling moth. This also has been effective against the mealybug. McCown continued to use lead arsenate in 1946 and 1947 and in this orchard more mealybugs have been found than in the other two. In 1948, this grower also changed to DDT in his summer spray program. DDT has apparently been very toxic to the parasites, especially *Allotropa* and *Pseudaphycus*. *Clausenia* seems to be able to come into DDT sprayed orchards in late season and parasitize individuals of the third generation.

The three orchards that have been discussed are all located within 3 miles of each other and they are the only commercial orchards in this small area. Four miles north and up the Ohio River are other commercial plantings but to date these have not become infested with mealybugs. Farther south, or down the river, there are no commercial orchards for about 15 miles. Here, near the village of South Point, in 1945 a rather severe infestation was found in the Brubaker orchard. According to the owners, mealybugs had been present for 3 or 4 years but they had not been reported previous to that time when about 60 per cent of all fruits were injured.

Parasites were liberated in this orchard in May 1946 and were recovered in collections of both the second (64.3 per cent) and third (83.1 per cent) generations. In 1947 and 1948 heavy schedules of DDT sprays were applied and practically eliminated both mealybugs and parasites.

CONCLUSION.—The history of the Comstock's mealybug for the 10 years that it has been known on apple in Ohio presents an excellent illustration of control by biological means, principally through the use of parasites. The continued and efficient correction of injury over a 6-year period by this means is most encouraging.

Development of Green Peach Aphid as Affected by Nutrient Deficiencies in a Host, Nasturtium[1]

JOHN S. BARKER[2] and OSCAR E. TAUBER,
Iowa State College, Ames, Iowa

Considerable interest has arisen in recent years as to effects of nutritional changes in host plants upon insect development and behavior. Dahm & Fenton (1940) concluded that increased nitrogen content in soil caused sorghum plants to be more susceptible to chinch bugs. Haseman (1946) has suggested that thrips favor plants grown under conditions of nitrogen starvation.

In connection with an aphid-rearing problem, an opportunity presented itself to record effects of N, P, K, Ca, or Mg deficiency in nasturtium upon the developmental period of *Myzus persicae*. Plants were grown in water cultures deficient in the respective elements. On appearance of characteristic nutrient deficient symptoms in the plant, apterous females were confined on leaves by means of cellophane bags. These females were allowed to deposit young for 4 to 5 hours, after which the adults were removed and a sample of 10 to 20 young was left on the caged leaf.

Days elapsing between this date and the date of maturity were recorded as the developmental period. Voluntary isolation by females at the time of reproduction made it possible to record individual developmental periods. Because all individuals composing a sample did not mature on the same day, each newly matured female and her respective young were removed from the enclosed leaf as soon as production of young was noted. Next, a new randomly selected sample of 10 to 20 young, within 4 to 5 hours in age, was taken from the maturing generation and caged on a different leaf. This process of selection was repeated for 10 generations.

Table 1.—Length of developmental period (in days) of the green peach aphid, *Myzus persicae*, reared on nasturtium, *Tropaeolum majus*, with known deficiencies of certain mineral nutrients.

	Replicates			Sum of Averages	Mean
	A	B	C		
Full Nutrient[1]					
No. Aphids	144	139	121		
Ave. (Days)	7.59	6.89	7.13	21.61	7.20
N Deficiency					
No. Aphids	89	85	78		
Ave. (Days)	7.44	7.29	7.14	21.87	7.29
P Deficiency					
No. Aphids	107	103	95		
Ave. (Days)	7.16	7.62	7.63	22.41	7.47
K Deficiency					
No. Aphids	73	92	94		
Ave. (Days)	7.88	7.34	7.00	22.22	7.41
Ca Deficiency					
No. Aphids	136	81	124		
Ave. (Days)	7.10	7.08	7.66	21.84	7.28
Mg Deficiency					
No. Aphids	81	113	103		
Ave. (Days)	7.64	7.24	7.08	21.96	7.32
Sum of Averages	44.81	43.46	43.64		
Mean	7.47	7.24	7.27		7.33

[1] Basically as recommended by Loomis & Shull (1937), but modified as indicated by Barker (1949).

Results are summarized in table 1. Three replicates (A, B, and C) of the entire procedure were run. Because of variation in sample size from one generation to the next, an average, weighted according to sample size, is reported for each treatment. Variation in the number of observations among replicates and treatments was largely due to difference in mortality rates on different plants.

An analysis of variance of the data presented in table 1 showed no significant difference among treatments.

It was concluded that, under these experimental conditions, the developmental period of *Myzus persicae* was not significantly influenced by those nutritional mineral changes to which *Tropaeolum majus* was subjected. The suggestion is made that more precise experimental procedures (for example, trying to determine the exact developmental period to the nearest *hour*, rather than in *days*), along with a larger number of generations, might show a slight increase in developmental period on the nutrient deficient plants. However, even with such refinements, it is doubtful if the variations would ever be of sufficient magnitude to warrant attempts at practical applications under field conditions where such minute and rigid control of variables would be virtually impossible.

Literature Cited

Barker, John Sam. 1949. Development and longevity of some plant lice as affected by nutrient deficiencies in their host plants. Thesis on deposit in Iowa State College Library, Ames, Iowa.

Dahm, R. G., and F. A. Fenton, 1940. The effect of fertilizers on chinch bug resistance in sorghum. JOUR. ECON. ENT. **33**: 688–92.

Haseman, Leonard. 1946. Influence of soil minerals on insects. JOUR. ECON. ENT. **39**: 8–11.

Loomis, W. E., and G. A. Shull. 1937. Methods in plant physiology. McGraw-Hill, N. Y.

[1] Journal Paper No. J-1869 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1102.

[2] Present Address: Agricultural Experiment Station, Pee Dee Station, Florence, South Carolina.

A Method of Dispersing Lindane Vapor in Air

W. N. SULLIVAN,[1] *U.S.D.A., Agr. Res. Adm. Bureau of Entomology and Plant Quarantine, Beltsville, Md.*

That lindane vapor is toxic to insects was shown by Slade (1945), and confirmed by Hoffman and Lindquist (1949) and Fulton *et al.* (1950). A new method of dispersing this vapor is now being developed.

Results to date indicate that the concentration of lindane vapor obtained in an enclosed space by the passage of an air stream through an air filter previously treated with lindane is sufficient to kill certain insects. The procedure is to apply 15 to 100 grams of lindane to a Fiberglas air-conditioning filter. The lindane is dissolved in acetone (1:7) and the solution applied with a spray gun to both sides

[1] The technical advice of F. H. Babers, J. J. Pratt, and R. A. Fulton and the assistance of M. S. Konecky in making the chemical analyses and of Robert Rogers in making the insect tests are gratefully acknowledged.

of the filter. The acetone soon evaporates, leaving a coating of crystals on the glass fibers. The use of this Fiberglas screen greatly increases the surface area of the lindane deposit, and the heavy deposit on the glass fibers gives a long-lasting source of lindane vapor. The filter has a coating of oil, which apparently helps to retain the lindane crystals. The Fiberglas filter (16 by 25 by 1 inches) can be purchased at any hardware store. The screen is fastened with wire to three points on the guard of a 10- to 16-inch household fan.

Operation of the fan causes an air current to flow through the filter and disperse the volatile lindane vapor pressure (0.03 mm. at 20° C.) to all parts of the treated room. Chemical analyses of the air from test rooms gave 0.000113 to 0.00026 mg. of lindane per liter. About 27 mg. of lindane has been liberated in an 8,500 cu. ft. room during a 1-hour test period.

The effectiveness of this minute amount of lindane vapor has been determined against flies, mosquitoes, grasshoppers, roaches, and Mexican bean beetles exposed in enclosed rooms (1,150 to 8,500 cu. ft.), a greenhouse (3,700 cu. ft.), and a bull barn (20,000 cu. ft., against horn flies only). From 80 to 100 per cent of adult house flies and mosquitoes (*Aëdes* and *Anopheles*) were killed within 24 hours after exposure for 1 hour. A 10-minute exposure gave a mortality of 74 to 100 per cent. All horn flies were knocked down in 90 minutes. Grasshoppers were somewhat harder to kill, and Mexican bean beetles and roaches showed little or no effect after a 1-hour exposure. The treated filters did not lose their effectiveness over a 2-month period.

It is probable that other partly volatile insecticides, such as chlordane, toxaphene, aldrin, dieldrin, β-butoxy-β′-thiocyanodiethyl ether, and mixtures of these materials would show similar promise when dispersed by this method.

In conclusion, it is emphasized that, although this method looks promising against certain insects, the effect of lindane vapor on humans and livestock has not been determined at this time. This method of application in buildings while occupied by man or livestock is, therefore, not recommended.

Literature Cited

Fulton, R. A., R. H. Nelson, and Floyd F. Smith. 1950. The toxicity of lindane vapor to insects. JOUR. ECON. ENT. **43**: 223–4.

Hoffman, R. A., and A. W. Lindquist. 1949. Fumigating properties of several new insecticides. JOUR. ECON. ENT. **42**: 436–8.

Slade, R. E. 1945. The gamma-isomer of hexachlorocyclohexane (Gammexane). Chem. and Ind. **40**: 314–9.

Control of Mites on Alfalfa and Clover Seed Crops[1]

E. C. KLOSTERMEYER, *Irrigation Experiment Station, Prosser, Washington*

In recent years, mites have become troublesome on many field and vegetable crops in the irrigated areas of central Washington. They have caused damage to potatoes, hops, beans, sugar beets, and peppermint. Of particular concern is the effects of the mites on alfalfa and red clover raised for seed production. Although the damage caused by the mites appears similar, a study of specimens collected from various hosts indicates that at least 3 species are involved, identified by E. A. McGregor as *Tetranychus bimaculatus* Harvey, *Tetranychus atlanticus*, McGregor, and an undescribed species of *Septanychus*. The mites on alfalfa were identified as *Septanychus* sp.

Table 1.—Effect of aerial application of dusts on mites on alfalfa. Grandview, Washington, 1950.

Date of Count	Live Mites per 100 Leaves			
	2% *Aramite*	4% *Aramite*	2% *EPN*	Sulfur
July 6 (pre-dust count)	127	305	299	345
July 8	105	62	95	252
July 13	906	209	108	194
July 20	216	131	194	467
July 26	262	47	119	1557
August 24	329	88	254	506
Total	1945	842	1069	3321

Enormous populations develop on legume seed crops, in many cases completely webbing over the plant and flowers, thus inhibiting pollination by bees. Severely attacked plants become dry prematurely. At the peak of infestation, the mites may cluster at the tips of the plants apparently in preparation for aerial dispersion. Masses of mites 0.25 inch in diameter have been observed on alfalfa. At such times it is possible to collect a tablespoonful of mites in a few sweeps of an insect net.

In 1950 certain acaricides were tested as dusts on alfalfa and red clover to determine their value in mite control. One test was made in a heavily infested 10 acre alfalfa seed field.[2] The field had been dusted earlier by plane with a combination of 10 per cent DDT and 70 per cent sulfur at 20 pounds per acre for lygus bug control. Since this failed to hold the mites in check, a dust of 1 per cent tetraethyl pyrophosphate was applied by air 2 weeks later, again failing in control.

On July 6, dusts of 4 per cent β chloroethyl (tertiary butyl phenoxy) α methyl ethyl sulfite,[3] 2 per cent of the same, and 2 per cent ethyl p-nitrophenyl thiobenzene phosphate,[4] were applied to one acre

Table 2.—Mite population per 10 leaves on red clover 10 days following application of dusts. Prosser, Washington, 1950.

Material	Treatment Mean
1% Tetraethyl pyrophosphate	445.0
Check	440.3
2% *EPN*[3]	246.0
4% *Aramite*[4]	66.0
LSD, 5% level	287.4

[1] Scientific paper no. 980, Washington Agricultural Experiment Stations, Institute of Agricultural Sciences, The State College of Washington, Pullman, Washington.

[2] The cooperation of Frank Omstead, Grandview, Washington, in making his field available for these tests and providing for aerial application is appreciated. Lee Cox, Prosser, Washington, piloted the dusting planes.

[3] E. I. du Pont de Nemours & Co., Inc.—(*EPN.*)

[4] Naugatuck Chemical Company.—(*Aramite.*)

unreplicated plots in this field with an airplane[1] at the rate of 50 pounds per acre. The remainder of the field was dusted with 84 per cent sulfur bentonite[2] at the rate of 50 pounds per acre using a Stearman bi-plane. The results were determined by counting the number of live mites from 100 leaves in each plot prior to dusting and at intervals thereafter. In sampling, 20 stems were taken at random and the mites on five trifoliate leaves from each stem counted (Table 1). Following the July 26 count, the grower dusted the entire field with 80 per cent sulfur.

A vital consideration in selecting insecticides to be used on alfalfa and clover seed fields is that the material be of low toxicity to honey bees and wild pollinating insects. Preliminary tests by H. F. Menke, Apiculturist, State College of Washington, indicate that *Aramite* is relatively non-toxic to honey bees and to *Nomia melanderi* Ckl. when the bees were confined to cages dusted with the 4 per cent material. *EPN*, however, resulted in 100 per cent mortality under the same conditions.

Best control was obtained on the plots receiving 4 per cent *Aramite*, this treatment consistently having a lower mite population in successive counts. The apparent increase in population on the July 13 count represents the mites which hatched from eggs present at the time of application. Few live mature mites were found at this count. Differences in mite population between the 4 per cent *Aramite* and the other treatments still occurred 8 weeks after application and the plants were noticeably healthier in appearance.

On red clover, dust treatments were made with a rotary hand duster on August 17. Four per cent *Aramite* dust was compared with 2 per cent *EPN*, 1 per cent tetraethyl pyrophosphate, and an untreated check on 405 square foot plots arranged in a randomized block design of 3 replications. Mite counts were made on 10 leaves per plot, 10 days after treatment. Differences between treatments were significant at the 5 per cent level, the 4 per cent *Aramite* treatment being markedly superior (Table 2).

[1] Piper Cub.
[2] Niagara Chemical Company. (*Kolodust*)

Injurious Effects of *Paracantha culta* on Canadian Thistle in Wisconsin

RAYMOND E. RYCKMAN, *Department of Medical Entomology, School of Tropical and Preventive Medicine, Loma Linda, California*

For the past three years phytophagous insects have been noticed working on Canadian thistles, *Cirsium arvense* Scop., growing 7 miles southeast of Shullsburg, Wisconsin. During the course of the 1950 growing season the above mentioned thistles were observed many times and the following data were recorded. When the flowering stalks reached approximately one-half maximum height and the terminal floral buds were visible, a large percentage of the plants began dying in the tops. Terminal growth of the flowering stalk ceased and the lateral branches then extended upward above the original top, which had previously died. Larvae and pupae removed from the dead and dying tops were reared through and the adults were identified as *Paracantha culta* (Wied.),[1,2]

Practically all the plants in the one-fourth acre plot under observation were infested with this fly, resulting in the destruction of nearly all the early blossoms and retarding the blooming time some 10 days. After the terminal buds were destroyed the flies were not able to reproduce as fast as lateral branches were produced by the plant, hence while the entire plot did reach blossom stage, it was retarded in time. Since some larvae were found dead it is possible that entomogenous organisms or entomophagous insects, or both, were inhibiting the fly population. By late summer *Paracantha culta* was unable effectively to prevent blossoming.

Paracantha culta has been previously taken from several species of thistles; this fly has been reported from *Cirsium nuttallii*, *C. horridulum* and *C. spinosissimum*,[3] In searching the literature it was found that *P. culta* has not to this date been reported from the Canadian Thistle, *Cirsium arvense*. This also would seem to be the first report of this insect from Wisconsin. Distribution records previously reported include Washington, Oregon, Idaho, South Dakota, Kansas, Texas, Louisiana, Georgia, Florida, South Carolina, North Carolina, Maryland and Delaware.[4]

[1] Trypetidae.
[2] Identified by Dr. Alan Stone of the Bureau of Entomology, Washington, D. C.
[3] Benjamin, F. H. 1934.
[4] Malloch, J. R. 1941, Doane, R. W. 1899.

Tests with Dieldrin for Control of Japanese Beetle Larvae in Turf[1]

J. ALFRED ADAMS, *New York State Agricultural Experiment Station, Geneva and Poughkeepsie, N. Y.*

Among the chlorinated hydrocarbons which are being tested for control of larvae of the Japanese beetle, *Popillia japonica* Newman, in grass turf are aldrin and dieldrin. Aldrin has been reported by Schread (1949) as comparing favorably with chlordane for this purpose. Concerning dieldrin there has been less information, probably because that product was not generally available till 1949, a year in which larval populations of the Japanese beetle were below normal in many areas. The author was fortunate in having fairly satisfactory populations at the site of some of the dieldrin plots which he established in that year.

The plots were located at the Hopewell Golf Links, 15 miles from Poughkeepsie, New York. The site was a low-lying field of long-established turf mowed to the 1-inch height a few times a year but otherwise uncared for. The vegetation consisted largely of oat grass, *Danthonia spicata*, with varying amounts of crab grass, *Digitaria sanguinalis*, and patches of mouse ear hawkweed, *Hieracium pilosella*. The oat grass, where predominant, had formed a shallow but tough sod. The soil, classified as Hoosic gravelly loam, was compact and poorly drained.

The plots, which were 25 by 40 feet, are listed in table 1. The dieldrin was obtained from the producer[2] as a 2.5 per cent dust. To ensure uniform application the total bulk to be spread on each plot was raised to 10 or 20 pounds by dilution with talc.[3] Mixing was performed in an orchard duster. A sample of the most dilute mixture used was analyzed

[1] Eastern Branch program, 1950. Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 845, December 4, 1950.
[2] Julius Hyman & Company. Denver, Colorado.
[3] EMTCO-23. Eastern Magnesia and Talc Company. Burlington, Vermont.

Table 1.—Surviving life forms of the Japanese beetle (except eggs) found in untreated check areas and in plots of 1000 sq. ft. treated with dieldrin. Hopewell Golf Links, Hopewell Junction, N. Y.

Plot	Dieldrin Toxicant to 1000 Sq. Ft. and Date Applied, 1949	Larvae and Pupae per Square Foot; June 27–29, 1950[1]		Apparent Reduction of 1949 Generation	Larvae per Square Foot; October 9–20, 1950	
		Untreated Checks	Treated Plots		Untreated Checks[2]	Treated Plots[3]
A	1 oz., Aug. 30	14.1	1.2	91.5%	36.0	0
B	1 oz., Aug. 30	17.3	2.4	86.1%	33.5	0
C	1 oz., Nov. 7	—	—	—	30.0	0
D	1 oz., Nov. 7	—	—	—	26.3	0
E	2 ozs., Nov. 7	17.6	3.1	82.4%	33.0	0
F	2 ozs., Nov. 7	11.9	1.5	87.4%	15.5	0
G	4 ozs., Nov. 7	—	—	—	12.5	0

[1] Each datum based on 10 square-foot samples, or 1 per cent of the area of each plot.
[2] Each datum based on 4 square-foot samples. The 28 check diggings also yielded a total of 9 eggs, one third instar of *Phyllophaga hirticula* (Knoch) and 3 larvae of *Autoserica castanea* Arrow.
[3] Each datum based on 10 square-foot samples. The 70 diggings also yielded 19 eggs and, on Plot F, one third instar of *Ph. hirticula*.

by the producer in 1950 and reported to have the expected dieldrin content. Application was made with a fertilizer spreader, without the addition of water. Part of the material applied remained exposed on the turf foliage for some time. In the first 2 weeks after the application on August 30 the total precipitation recorded at the Poughkeepsie Airport, four miles from the site, was 0.12 inch; the total for the month after application was about 2.5 inches. Air temperature for September ranged from 87 to 33 degrees F. with an average of 60 degrees. (Weather Bureau 1949)

Each plot was considered as having its own check area, consisting of the untreated soil within about 6 feet of the plot. On September 6, 1 week after treatment, four square-foot diggings in plots A and B combined yielded an average of 32 larvae to the square foot; four check diggings averaged 23 larvae. On September 28, 6 square feet in the plots averaged 21 larvae healthy, 1 moribund and 1 dead. On November 3, 4 square feet in the plots yielded an average of 16 larvae, while four checks yielded an average of 32. Between April 19 (1950) and May 25, 10 square feet in plot A yielded an average of 4.7 larvae, while 10 checks yielded an average of 26.6. The final June sampling is summarized in table 1. Of the survivors in the checks, 60 per cent had pupated; of the survivors in the plots, 54 per cent had pupated. Some of the larvae in the plots appeared moribund and some dead prepupae and pupae were found. On the five plots treated in November, 1949, larvae and pupae were readily found in June, 1950, but since the check populations for three of them were low, only E and F were fully sampled at that time. By October 1950 control was complete with all the treatments.

Discussion.—The apparent retardation in the control of the first generation may have been due to factors tending to delay contact between the toxicant and the larvae. Rain, which is considered helpful in carrying dry insecticides into turf, was almost lacking in the fortnight after application. The oat grass sod was probably exceptionally resistant to penetration by the insecticide. Also operative may have been the factors which tend to retard control in poorly drained soil, as reported with chlordane by Fleming (1948). Standard methods of measuring and describing turf conditions would be helpful in studies of this kind.

Summary.—Dieldrin, highly diluted with talc, was applied dry on long-established turf on poorly drained, compact soil. After application at 1 ounce to 1000 square feet (equivalent to 2.7 pounds to the acre) in August, 1949, mortality of Japanese-beetle larvae was gradual, leading to a reduction of about nine-tenths by late June, 1950. On plots treated at the rate of 2 ounces to 1000 square feet (5.4 pounds to the acre) in November, 1949, the reduction the following June approached nine-tenths. On all plots treated in 1949 at 2.7, 5.4 and 10.8 pounds to the acre, control was complete by October, 1950.

Literature Cited

Fleming, W. E. 1948. Chlordane for control of Japanese beetle larvae. Jour. Econ. Ent. **41**(6): 905–12.

Schread, J. C. 1949. A new chlorinated insecticide for control of turf-inhabiting insects. Jour. Econ. Ent. **42**(3): 499–502.

Weather Bureau (1949): Climatological Data, New York **61**(8): 178; (9) 119, 213; (13) 299. U. S. Dept. of Commerce, Albany, N. Y.

Henry G. Herrell in New Post

On January 12, 1951, Henry G. Herrell was appointed Deputy Assistant Chief of the Bureau of Entomology and Plant Quarantine, in which position he will assist in the direction of all Bureau administrative management functions and operations. Mr. Herrell started in the Bureau of Plant Industry in 1927 and has progressed through various administrative grades, and has held various positions of responsibility. In 1930 he received an LL.B. from National University and in 1933 a BCS degree in accounting from Ben Franklin University. He is a member of the District of Columbia Bar Association.

PROCEEDINGS OF THE SIXTY-SECOND ANNUAL MEETING

OF THE

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Denver, Colorado, December 18, 19, 20 and 21, 1950

The Association met at Denver, Colorado, December 18–21, 1950 at the Cosmopolitan Hotel. The Executive Committee met on December 17. The Entomological Society of America held their meetings at the same time with headquarters at the Shirley Savoy Hotel. The Committee on Local Arrangements was headed by George M. List, Fort Collins, Colorado. Claude Wakeland acted as Vice-Chairman of the local committee consisting of Messrs. Hugo G. Rodeck, Jim Dutton, W. E. McCauley, F. H. Gates and B. T. Snipes. This committee performed its various functions in a most commendable manner. There were 474 registered during the meeting in addition to 42 ladies who accompanied members and guests. A special program was carried out of entertainment for the ladies.

The program committee, L. D. Christenson, Chairman, arranged a number of joint sessions with the Entomological Society of America and the Executive Committees met in joint session, likewise.

The banquet on Tuesday night was sold out completely and a very excellent dinner and pleasant time was enjoyed by all. Delightful entertainment for this occasion was furnished by members of the Allied Industries. On Wednesday night the Julius Hyman Company and the Shell-Chemical Corporation were hosts to the entire membership at a splendid dinner followed by excellent entertainment. The Allied Industries were hosts for the ladies' tour, luncheons, and the cocktail party preceding the banquet.

PRELIMINARY MEETING
December 18, 1950

President Clausen presiding:

President Clausen announced the appointments that he had made during the year, as follows:

Editor and editorial committee of *Entoma:*

Dr. Geo. S. Langford, *Editor*
Dr. J. C. Weinman
M. O. I. Snapp
Mr. J. C. Gaines
Dr. A. M. Stafford
Mr. R. C. Roark
Mrs. R. L. Busbey

Committee to consider use of Illustrative Material at Branch Meetings and to consider possibilities for improvement in presentation of material:

M. P. Jones
C. E. Palm
J. L. Horsfall

Local Arrangements Committee for 1950 Denver Meeting:

George M. List, *Chairman*
Claude Wakeland, *Vice-Chairman*
B. Thomas Snipes
W. E. McCauley
Hugo G. Rodeck
F. H. Gates
Jim R. Dutton

Earlier in the year, representatives were appointed to attend the national conference of non-governmental organizations of FAO organizations:

Dr. F. C. Bishopp
Mr. C. M. Packard

It is customary for the Association to be represented at the inauguration ceremonies of various state institutions, particularly where entomological work is under way, and invitations were received during the year for inaugural ceremonies at three state institutions:

University of North Carolina, October 8–10, 1950, for inauguration of President Gordon Gray. Representative: Prof. W. J. Schoene

Texas A. & M. College, October 12, 1950, for inauguration of President M. T. Harrington. Representative: W. E. Laake

Utah Agricultural College, October 17, 1950, for the inauguration of President W. L. Madsen. Representative: W. L. Orr

Resolutions Committee to act at present meeting and bring in report at the end of the convention:

H. B. Mills, *Chairman*
J. J. Davis
E. H. Littooy

COMMITTEE REPORTS

The report of the secretary was read. The report of the auditor was read. It was regularly moved and seconded that it be accepted. This was carried. The recommendations of the Executive Committee were read and regularly moved and seconded that it be accepted. This was carried. The report of the Committee on Common Names was read by E. Gorton Linsley. This was regularly moved, seconded, and carried. Report of the Committee on Insecticide Terminology was presented by Dr. C. O. Eddy. It was regularly moved, seconded that the report be adopted. This was carried. The report of the Counselor for the AAAS was accepted. The report on the Committee on Illustrative Material was regularly moved and seconded for adoption and passed. A brief report on the Joint Committee on the History of Entomology was presented by Paul W. Oman and was accepted. The report of the Representative to the National Research Council by Dr. Floyd Smith was accepted. A brief report of the National conference of non-governmental organizations of FAO was presented by Dr. F. C. Bishopp. This was accepted.

REPORT OF THE SECRETARY-TREASURER

Despite a serious loss due to non-payment of dues the Association continues to increase in membership. There have been approximately 100 dropped for non-payment. The word, approximately, is used advisedly as there are constant requests for reinstatement that change this number overnight. There have been 22 resignations, 14 deaths, and approximately 320 new members. The total membership as shown by the addressograph lists plus those just admitted stands at 2,438. After tedious correspondence it has been ascertained that of the long list of foreign members only 14 are known to be alive.

The audit by certified public accountants will show a better bank balance than in the previous audit, but the membership must realize that costs are constantly rising and in my estimates I have made allowance for substantial increases in printing costs, in travel, and in the new income and social security taxes, which this Association may have to pay beginning January 1, 1951.

The next meeting of the Entomological Societies will be held jointly with the American Phytopathological Society at Cincinnati, Ohio, December 9 to 13, 1951. Headquarters will be at the Netherlands-Plaza Hotel. This promises to offer unsurpassed opportunities for better understanding and greater services to the nation.

The Roster of Scientific Personnel should be of great utility in the mobilization of the scientists. Each member of this society will receive a questionnaire in the near future. Be certain that you complete and return it without delay. Fill it out as soon as you get it. The need for speed has necessitated the reduction of many categories, but opportunity is afforded under the title "OTHER" to be specific about your experience and skills.

The members will be gratified to know that another entomological society is affiliating with this Association. The Georgia Entomological Society has petitioned for affiliation and the Executive Committee has made a recommendation that will come before you this morning for action.

The IX International Congress of Entomology will convene in Amsterdam, the Netherlands, from the 17th to the 24th of August, 1951. Dr. J. C. Bradley is the representative for the U.S.A. on the Permanent Committee on the Congress. The Honorary General Secretary is J. deWilde, 136 Rapenburgerstraat, Amsterdam.

Two of the Branch meetings are announced in the October Journal. The Cotton States meeting will be at the Hotel Peabody, Memphis, Tennessee, February 5, 6, and 7. The Southwestern meeting will be at the Hotel Adolphus, Dallas, Texas, March 1 and 2, and the North Central States will meet at the Commodore Perry Hotel, Toledo, Ohio, March 21 and 22. The Pacific Slope Branch will meet at Seattle, Washington, June 19–20–21, 1951 at the Edmund Meany Hotel.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

FINANCIAL STATEMENTS

For the fiscal year ended November 30, 1950

December 11, 1950

Dr. C. P. Clausen, President,
American Association of Economic Entomologists,
Bureau of Entomology and Plant Quarantine,
Washington 25, D. C.

Dear Dr. Clausen:

In accordance with the recent request of Dr. Ernest N. Cory, I have examined the accounting records of the Secretary-Treasurer of the American Association of Economic Entomologists for the fiscal year ended November 30, 1950, and present herewith statements of receipts and disbursements of the General Fund, Permanent Fund and Special Journal Fund for the year, which were prepared from the records.

The examination included such tests and checks as were deemed necessary and adequate in the circumstances. However, a detailed audit was not made.

In my opinion, the accompanying statements accurately reflect the recorded cash receipts and the authorized disbursements made for the benefit of the Association during the period. The balances of cash and securities at the beginning and at the end of the period were verified by me by actual count or were confirmed directly by the bank.

Very truly yours,
JOHN A. HERL

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

GENERAL FUND

Statement of Receipts and Disbursements
For the fiscal year ended November 30, 1950

	Total	*Journal*	*Association*	*Indices*
Receipts:				
Subscriptions	$17,135.01	$17,135.01		
Advertising	2,982.40	2,982.40		
Reprints	2,223.39	2,223.39		
Back Numbers and Miscellaneous	2,819.32	2,819.32		
Dues—1951	4,105.00		$3,420.83	$ 684.17
1950	2,643.50		1,982.62	660.88
1949	240.00		180.00	60.00
1948 and Prior Years	59.00		44.25	14.75
Sale of Indices	345.50			345.50
Interest on Bonds	50.00		50.00	
Cash Overage	11.50		11.50	
Federal Income Tax—withheld but not yet paid	95.45		95.45	
Total Receipts	$32,710.07	$25,160.12	$5,784.65	$1,765.30
Disbursements:				
Journal Costs—Printing and Mailing	$17,762.26	$17,762.26		
Engravings	676.29	676.29		
Salaries and Wages—Stenographic and Clerical	3,162.70	1,581.35	$1,581.35	
Honorarium—Editor	600.00	600.00		
Honorarium—Business Manager and Secretary-Treasurer	600.00	300.00	300.00	
Postage, Stationery and Office Supplies	1,078.64	539.32	539.32	
Travel Expense	514.13		514.13	
Branch Expenses Reimbursed—North Central States	225.56		225.56	
Accounting Service	175.00	87.50	87.50	
Telephone and Telegraph	17.09		17.09	
Insurance and Fidelity Bond	44.84	22.42	22.42	
Rental—Safe Deposit Box	7.20		7.20	
Refunds—Subscriptions and Back Numbers	183.69	183.69		
Advertising Commissions	26.25	26.25		
Meetings Expense	546.53		546.53	
Collection and Bank Charges	28.74	14.37	14.37	
Federal Income Tax—withheld 1949 paid in 1950	73.25		73.25	
Total Disbursements	$25,722.17	$21,793.45	$3,928.72	$ —0—
Excess of Receipts over Disbursements	$ 6,987.90	$ 3,366.67	$1,855.93	$1,765.30
Balance, December 1, 1949	11,338.93	−975.16	7,026.60	5,287.49
Balance, November 30, 1950	$18,326.83	$ 2,391.51	$8,882.53	$7,052.79

RECAPITULATION

Prince Georges Bank & Trust Company—Checking Account	$16,326.83
U. S. Savings Bonds, Series G, 2½%—Cost	2,000.00
Total Cash and Securities	$18,326.83

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

PERMAMENT FUND

Statement of Receipts and Disbursements
For the fiscal year ended November 30, 1950

Balance, December 1, 1949		$17,340.42
Receipts:		
Interest on Bonds—Prior Year	$ 279.36	
Interest on Bonds—Current Year	361.25	
Interest on Savings Deposit	7.25	
Increment to redemption value of U. S. Savings Bonds, Series F	32.50	
Life Memberships:		
One at $100.00	100.00	
Two at $50.00	100.00	
Total Receipts		880.36
Fund Balance after Receipts		18,220.78
Disbursements:		
None		—0—
Balance, November 30, 1950		$18,220.78

RECAPITULATION

Securities

Face Value		*Book Value*	
$ 2,000.00	Province of Ontario 5% Debenture Bonds of 1959, at cost	$2,000.00	
3,000.00	U. S. Treasury 2⅞% Bonds of 1955–60 at cost	2,984.00	
7,000.00	U. S. Savings Bonds, Series G, 2½% at cost	7,000.00	
6,500.00	U. S. Savings Bonds, Series F, at current redemption value	4,842.50	
$18,500.00	Total Securities		$16,826.50

Cash

Prince Georges Bank & Trust Company—Savings Account	1,394.28
Balance, November 30, 1950	$18,220.78

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

SPECIAL JOURNAL FUND

Statement of Receipts and Disbursements
For the fiscal year ended November 30, 1950

Balance, December 1, 1949	$522.60
Receipts:	
Interest on Savings Deposit	5.00
	$527.60
Disbursements:	
None	—0—
Balance, November 30, 1950	$527.60

RECAPITULATION

Prince Georges Bank & Trust Company—Savings Account	$527.60

Georgia Entomological Society
632 Mulberry Street
Macon, Georgia

Mr. E. N. Cory, Secretary

October 9, 1950

American Association of Economic Entomologists
College Park, Maryland

Dear Sir:

This letter will serve as a petition for affiliation of the Georgia Entomological Society with the American Association of Economic Entomologists. This petition has had the formal approval of all members of the Georgia Entomological Society through a written mail ballot. Membership in the Georgia Entomological Society is drawn from the entire State of Georgia and the Society has been in existence for 13 years. There are 59 paid-up members enrolled. A list of the active members is attached hereto.

The Georgia Entomological Society is a self-supporting organization that sponsors a meeting at least once a year, at which time entomological subjects of interest to the group are discussed. During such meetings a number of speakers present the latest information on the entomological work in which they are engaged and tours are conducted to laboratories and other points of interest. The annual dues for membership in this Society are $1.00 per year. This fee is, of course, not sufficient to cover the publication of a magazine, but information of interest to the group is circulated at unscheduled intervals through the office of the secretary-treasurer of the Society.

The present officers of the Georgia Entomological Society are: G. G. Rohwer, President; Mr. Thomas M. Gunn, Vice-President; and Dr. Horace O. Lund, Secretary-Treasurer.

The favorable consideration of this petition will be appreciated. Sufficient copies of this letter are enclosed so that they may be forwarded to each member of the Executive Committee.

Mr. Thomas M. Gunn, the Vice-President, was recalled to active duty in the Navy and therefore is not available to sign this petition.

Sincerely yours,
Georgia Entomological Society
G. G. Rohwer and Horace O. Lund
President *Secretary-Treasurer*

Active Members of the Georgia Entomological Society, 1950

Alden, C. H., Ga. Dept. Entomology, State Capitol Bldg., Atlanta, Ga.
Alden, John C., Woolfolk Chemical Wks, Ltd., Fort Valley, Ga. (P.O. Box 922)
Allison, F. E., Calif. Spray Chemical Co., Tifton, Ga.
Anderson, Roger F., Biology Dept., University of Ga., Athens, Ga.
Basinski, E. R., Rt. #1, Zebulon Rd., Macon, Ga.
Beckham, C. M., Ga. Expt. Sta., Experiment, Ga.
Blasingame, Bill Eugene, Ga. Dept. Entomology, Capitol Bldg., Atlanta, Ga.
Bond, Joseph W., American Cyanamid Co., P.O. Box 30, Toccoa, Ga.
Brabson, Max L., Demorest, Ga.
Breeland, Sam G., Box 246, Camilla, Ga.
Burgoyne, James C., P.O. Box 1095, Macon, Ga.
Cowart, F. F., Experiment, Ga.
Culpepper, Lawton M., Box 632, Fort Valley, Ga.
Davis, W. H., P.O. Box 632, Fort Valley, Ga.
Dodge, Capt. H. R., C.D.C. Lab. Services, 291 Peachtree St., Atlanta, Ga.
DuPree, Minter, Expt. Sta. Experiment, Ga.
Edwards, William E., P.O. Box 284, Butler, Ga.
Fancher, C. C., 632 Mulberry St., Macon, Ga.
Fattig, P. W., The Museum, Emory University, Emory University, Ga.
Fletcher, Orlin K., P.O. Box 558, Albany, Ga.
Fortson, Weston M., Box 504, Waynesboro, Ga.
Geiger, P. G., P.O. Box 212, Fitzgerald, Ga.
Gilmer, Paul M., Ga. Coastal Plain Expt. Sta., Tifton, Ga.
Goodwin, Maj. M. H., Dept. of Biology, University of Georgia, Athens, Ga.
Greene, L. C., P.O. Box 361, Vidalia, Ga.
Gunn, Tom, Orkin Experimenating Co., 591 Peachtree St., Atlanta, Ga.
Haines, Thomas W., P.O. Box 270, Thomasville, Ga.
Hayes, Harold B., P.O. Box 466, Waynesboro, Ga.
Hollon, Julius P., B.E.P.Q., P.O. Box 527, Fort Valley, Ga.
Johnson, Martin L., Biology Department, Univ. of Georgia, Athens, Ga.
Knight, G. B., P.O. Box 212, Fitzgerald, Ga.
La Hue, D. W., Coastal Plain Expt. Sta., Tifton, Ga.
Legwen, W. A., P.O. Box 1095, Macon, Ga.
Loden, H. D., Agronomy Dept., Univ. of Georgia, Athens, Ga.
Lund, H. O., Biology Dept., Univ. of Georgia, Athens, Ga.
McCroan, Dr. John E., Jr., Ga. Dept. Public Health 12 Capitol Sq., S.W., Atlanta 3, Ga.
McDonald, Bobby R., R. #1, Mount Vernon, Ga.
Moore, Glenn E., Box 181, Tifton, Ga.
Morgan, L. W., Coastal Plain Expt. Sta., Tifton, Ga.
Morlan, Capt. Harvey B., C.D.C.A. Station, Thomasville, Ga.
Parkinson, Kenneth R., 632 Mulberry St., Macon, Ga.
Persons, T. D., 311 Professional Bldg., Macon, Ga.
Pollard, Hershel N., U.S.D.A., B.E.P.Q., Phony Peach Disease Lab., Fort Valley, Ga.
Redmond, W. P., Biology Department, Emory University, Emory University, Ga.
Rigsby, James H., P.O. Box 372, Cordele, Ga.
Rohwer, G. G., 632 Mulberry St., Macon, Ga.
Saylor, Maj. Lawrence, 605 Volunteer Bldg., Atlanta, Ga.
Seago, John M., 291 Peachtree St., Atlanta, Ga.
Sheffield, A. E., Route #2, Leary, Ga.
Shepard, C. E., Room 311, Professional Bldg., Macon, Ga.
Smith, Carl W., 632 Mulberry St., Macon, Ga.
Snapp, O. I., Bureau of Ent. & Plant Q., Fort Valley, Ga.
Spitler, Garth, Coastal Plain Exp. Sta., Tifton, Ga.
Swank, G. R., P.O. Box 914, Fort Valley, Ga.
Thames, Walter H., Jr., Everglades Experiment Sta., Belle Glade, Florida
Towson, Willard E., Biology Dept., University of Georgia, Athens, Ga.
Turner, W. F., P.O. Box 162, Fort Valley, Ga.
Vann, Irvin B., Sr., P.O. Box 247, Edison, Ga.
Williams, Laney C., P.O. Box 31, Dublin, Ga.

REPORT OF THE EXECUTIVE COMMITTEE December 17, 1950

1. It was recommended that a brief biographical statement shall accompany the ballot for President and First Vice-President. The sketch is to include name, address, college or colleges, present affiliation, and date the candidate became a member of the Association. The Secretary is instructed that he shall notify each nominator that it is essential in order to get his nominee's name on the ballot, that he certify that he has consulted his nominees and has assurance that they will allow their names to be printed on the ballot and will serve if elected. The certificate shall read:

"I have conferred with my nominees and they have agreed to have their names on the ballot and serve if elected."

Signed _____ Nominator

2. The petition of the Georgia Entomological Society was accepted and favorable action was recommended to the membership.

3. The incoming President is authorized to appoint delegates and alternates to the IX International Entomological Congress.

4. A limitation of 2,500 copies was placed on the edition of Index 8.

5. A proposal from the American Phytopathological Society for joint action in regard to a proposed new periodical was acted upon as follows:

"In view of the pending consolidation of the entomological societies and because of the state of emergency, this Association considers that it would be unwise to consider the proposal for a new periodical at this time."

6. The resolutions from the Pacific Slope Branch and the North Central States Branch were considered but tabled because of the pending consolidations and changes in the constitution and by-laws.

7. Due to the pending consolidation and consequent changes in policy, constitution and by-laws, many topics that would normally be the subject of recommendation have been considered, but action has been deferred. This report and its recommendations were approved.

EXECUTIVE COMMITTEE MEETING December 20, 1950

The Executive Committee of the A.A.E.E. recommends that:

1. The Report of the Joint Committee on Consolidation be accepted in principle.
2. The proposed consolidation of the two societies is both feasible and desirable and in order to effect this merger, the following steps be taken, subject to a final determination by two-thirds favorable vote by letter ballot.
   - A. Read the proposed constitution for the information of the membership.
   - B. Authorize the submission of copies of the proposed constitution and by-laws to the entire membership within six months.
   - C. Authorize a single ballot on the acceptance of the proposed constitution. Such merger, however, will be contingent upon acceptance by a two-thirds favorable vote of the ballots cast in each society.

EXECUTIVE COMMITTEE MEETING December 18, 1950

This meeting was called to act upon two items. The first was a presentation by Mr. Bruce Gleissner of the proposal to publish a new manual on testing techniques. After a great deal of discussion it was referred to the section on Insecticides with the statement that the Parent Association is sympathetic towards the effort to obtain publication of this manual but that the impetus for its publication should come from the section on Insecticides. A second item of discussion by a large number of representatives of the Pacific Slope Branch was in regard to the position of Colorado and the change of name of the Branch. It was stated that the Pacific Slope Branch will probably leave out the word "Slope" and revise the constitution as Colorado has definitely affiliated with the North Central Branch. It was further stated that all other states in the Inter-Mountain area with the exception of New Mexico and Colorado are considered to belong to the Pacific Branch.

FINAL BUSINESS MEETING December 21, 1950

President Clausen presiding:

Report of the Membership Committee was presented by W. B. Wood and it was regularly moved and seconded that this be accepted. This was carried. A brief report on *Entoma* was presented. The report of the Joint Committee on consolidation was read and a motion for the adoption for the recommendations of the Executive Committee as outlined above was carried unanimously.

The secretary was authorized to set a deadline on counting of ballots as of 2 months following the mailing of the constitution. The letters are to be accompanied by envelopes marked "Ballot." The secretary is authorized to select a Tally Committee of three. The report on Nominating Committees was read by Roy G. Richmond and it was moved and seconded that the nominations be closed. This was carried and then it was regularly moved that the Chair be authorized to accept the nominees as presented. The report of the Resolutions Committee was presented by Harlow B. Mills and a motion was made that all the resolutions read be adopted. This was seconded and carried unanimously. The reports are printed following these minutes.

The incoming President, Roy E. Campbell, was then escorted to the chair by Messrs. List and Bishopp. He was presented the gavel by President Clausen and responded briefly in assuming the duties of President.

REPORT OF THE COMMITTEE ON MEMBERSHIP FOR THE YEAR 1950

The Committee on Membership has considered the applications of 320 persons. The data on the applications as in previous years, has been summarized by the committee chairman and summaries have been mailed to members of the Committee for a record vote on each applicant. Upon return of the ballots a list of the persons elected has been sent to the Secretary of the Association and a copy to the Editor. The applications properly certified, have been filed with the Secretary after committee action. It has been necessary in several instances to return applications for more complete information, for signatures or for other reasons. This has caused delay in acting on some individual cases.

Three hundred and twenty one applicants have been approved for active membership in the Association during the present year. The names of the new members are given in an appended list. One application for life membership, that of Julian M. Juantorena has been approved.

Twenty two active members have resigned during 1950 and 127 have been dropped for nonpayment of dues. Death has claimed the following 14 members:

Adams, C. F., 1/21/50
Annand, P. N., 3/29/50
Barber, H. S., 6/1/50
Bemis, W. G., 3/2/50
Bondy, F. F., 7/19/50
Brewer, E. G., 10/20/50
Eddy, Brayton, 7/17/50
Howard, L. O., 5/1/50
Mason, A. C., 5/16/50
Morgan, H. A. 8/25/50
Plummer, A. O., 4/26/50
Telford, P. E., 1/29/50
Wehrle, L. P., 10/22/50
Yetter, W. P., 6/17/50

Respectfully submitted,

L. A. CARRUTH
EPHRIAM HIXSON
W. N. KEENAN
W. W. STANLEY
H. L. SWEETMAN
W. B. WOOD, *Chairman*

MEMBERS ELECTED IN 1950

Abarca, Miguel
Aburto, Horatio
Alberty, A. L.
Allen, C. A.
Allen, F. A.
Amen, C. R.
Andahl, W. B.
Anderson, E. C.
Anderson, E. D.
Anderson, Lorin
Anderson, N. L., Jr.
Armstrong, A. E.
Ash, A. C.
Baker, G. J.
Ball, H. J.
Bannon, R. R.
Barker, J. S.
Barnard, C. O.
Barnes, Douglas
Barrett, W. W.
Bartges, R. J.
Bascom, L. A.
Bashor, E. F.
Bayha, K. W.
Beckman, H. F.
Benedict, S. H.
Bernardin, P. E.
Biddle, C. M., 3d
Bidlingmayer, W. L.
Bingaman, C. A.
Blackledge, W. T.
Bloom, R. U.
Bodman, M. T.
Bonino, G. B.
Bovard, J. E.
Bower, C. A.
Bowles, E. J.
Boyd, W. I.
Bray, D. F.
Briggs, J. D.
Brook, T. S.
Bulger, W. O.
Burden, G. S.
Burrage, R. H.
Burk, V. F.
Burkhardt, C. C.
Butcher, F. D.
Cain, T. L., Jr.
Calvin, L. D.
Carlson, D. A.
Casida, J. E.
Chadbourne, D. S.
Chandler, H. P.
Chandler, Leland
Chase, R. R.
Chiang, H. C.
Claborn, H. V.
Clark, E. C.
Coffin, O. T.
Coles, L. W.
Cook, S. E., Jr.
Cooke, C. B.
Corkins, J. P.
Corrin, W. R.
Cox, H. C.
Crall, H. W.
Daugherty, D. M.
Davich, T. B.
Davidson, E. H.
Davies, D. M.
Davis, Z. T.
Dean, W. P.
Degginger, Edward
Del Campo, O. G.
DeLeon, Donald
Denmark, H. A.
DeTar, J. E.
Diaz, Joe
Dickason, E. A.
Dixon, R. E.
Dowling, C. F., Jr.
Drooz, A. T.
Dunn, W. J.
Dutky, S. R.
Earle, Norman
Edmands, Mary J.
Ellertson, F. E.
Elmer, C. H.
Elmore, C. M., Jr.
Esberg, A. M.
Estrada, R. F.
Faloon, O. J.
Fathy, A. A.
Fisher, F. E.
Flitters, N. E.
Fluno, J. A.
Flynn, J. E.
Franz, A. J.
French, C. F.
Fronk, L. E.
Fuller, F. M., Jr.
Gerber, C. E.
Gibbs, L. W.
Goleman, D. L.
Goodwin, W. J., Jr.
Goulding, R. L., Jr.
Gow, P. L.
Gray, E. G.
Griggs, W. N.
Groves, K. D.
Gunn, T. M.
Gunter, A. C.
Haas, G. E.
Haflinger, Ernest
Hagelin, J. A.
Ham, G. F.
Hantsbarger, W. M.
Haramoto, F. H.
Harris, E. D.
Harrison, R. J. R.
Harvey, T. L.
Harwood, R. F.
Hassler, Karl
Heald, H. L.
Hefferman, T. H.
Heidt, J. H.
Herman, F. A.
Herring, R. K.
Hodge, C. R.
Hopkins, Lemac
Hopla, C. E.
Hough, S. B.
Huff, G. E.
Hunsucker, C. L.
Hunt, C. R.
Huse, W. E.
Hyry, Edmund
Jackson, W. E.
Johnson, D. E.
Johnson, E. C.
Johnson, H. L.
Johnson, M. McD.
Jonson, W. S.
Kardos, E. H.
Kaspar, P. E.
Katz, Harry
Keh, Benjamin
Keil, J. E.
Keithly, S. R.
Kido, Hiroshi
King, D. R.
Kline, Joseph
Kohler, P. H.
Konecky, M. S.
Krall, J. L.
Kriner, R. R.
Lake, J. W.
Lang, W. H.
Lazarus, Edwin
Lea, A. O., Jr.
Leigh, T. F.
Levin, M. D.
Lienk, S. E.
Lloyd, G. W.
Lofgren, J. A.
Lupsha, C. H.
McAdams, R. W.
McCord, G. D.
McCoy, K. E.
McNeel, W., Jr.
McNeely, L. B., Jr.
Ma, Shih Chun
Maclang, F. A.
MacDonald, B. C.
Madsen, L. S.
Martin, E. C.
Martin, G. E.
Mathewson, J. A.
Menke, H. F.
Merkl, M. E.
Metze, R. W., Jr.
Miller, Albert
Miller, C. W.
Miller, H. C.
Miller, R. E.
Miller, R. N.
Miller, R. S.
Mills, T. W.
Mitchell, E. B.
Mitlin, Norman
Mizell, F. M.
Moffett, J. O.
Moore, A. D.
Moore, D. H.
Moore, Stevenson, 3d
Morgan, K. C.
Mulla, M. S.
Mundinger, F. G.
Munger, G. O., Jr.
Murphy, D. R.

Murphy, G. I.
Murray, J. E.
Neal, J. H.
Nielsen, G. E.
Nishida, Toshiyuki
Norland, C. E.
Norris, A. L.
Norton, R. J.
Owen, W. O.
Pappas, Joe
Patton, J. W.
Paul, J. J.
Perry, A. S.
Peterson, C. O.
Pierce, T. A.
Portman, R. F.
Pospichal, A. T.
Powers, D. L.
Poyner, M. M.
Pratt, R. M.
Pruitt, S. H.
Puttarudriah, M.
Raffensperger, E. M.
Rao, A. M.
Rathburn, C. B., Jr.
Reeks, L. D., Jr.
Reinking, R. B.
Reno, P. J
Retzloff, A. F.
Rhode, R. H.
Richards, D. J.
Richardson, Curtis
Rider, F. L., Jr.
Roberts, F. S.
Robertson, R. S., Jr.
Robinson, D. W.
Rogers, R. E.
Roth, L. M.
Ruda, Edwin
Ruppel, R. F.
Rust, R. E.
Rutschky, C. W.
Schendel, R. R.
Schmid, G. R.
Schoch, W. S.
Schroeder, E. F., Jr.
Schwab, William
Scott, D. R.
Selby, J. W., Jr.
Semel, Maurie
Sempliner, Myron
Shankland, D. L.
Simeone, J. B.
Simonds, J. M.
Simpson, R. W.
Sisson, R. L.
Smith, Nelson
Smith, O. J.
Snow, S. J.
Soroker, R. H.
Spawn, G. B.
Spitzer, C. H., Jr.
Stansbury, R. E.
Stathis, A. L.
Statler, M. W.
Stephen, W. A.
Stern, V. M.
Sternburg, James
Stiles, H. R.
Strickland, L. F.
Sturdy, R. A. (D.V.M.)
Taylor, B. C.
Taylor, Jack
Taylor, L. F.
Taylor, P. S.
Teague, C. P.
Teer, H. L.
Thomas, R. W.
Thompson, W. W.
Thornton, N. C.
Tissol, Mrs. C. E.
Toczydlowski, A. H.
Tomasek, H. F.
Tuft, T. O.
Uddin, Zia
Vaughn, S. H.
Vinson, E. B.
Wade, W. H.
Walbolt, D. H.
Walker, C. E.
Walker, N. A.
Wall, W. J., Jr.
Wallace, L. E.
Wattal, B. L.
Watts, Miss H. A.
Weldon, G. H.
Wellhausen, E. J.
Wells, L. F., Jr.
Weston, E. C.
Whitbeck, Caleb
White, A. N., Jr.
White, Loring
Wyard, W. W., Jr.
Williams, J. N.
Williams, P. H.
Wilson, B. L.
Wilson, F. L.
Wilson, J. R. W.
Witherington, C. G.
Wong, Jack
Wood, E. A., Jr.
Woodbury, H. A.
Wymer, W. H.
Wu, I.
Young, H. C.
Youngblood, N. W.
Yuasa, Hiroharu
Zimmerman, R. E.
Zipperer, K. E.
Zuhl, H. A.

Report of the Committee on Insecticide Terminology

The development of coined names for promising insecticidal chemicals again has been the principal activity of this Committee during the past year. The Committee has continued to work closely with the Federal Interdepartmental Committee on Pest Control. That Committee, which develops names jointly with several other groups interested in pesticides, has arranged to work in cooperation with similar committees in Canada and in England—a step that should lead to the establishment of names that are internationally useful. The fact that the Federal Committee has assumed leadership in this undertaking should not deter members of this Association from suggesting names for any new material. The Committee on Insecticide Terminology would welcome constructive contributions.

One name, allethrin, was adopted during the year. Names for several other materials are under consideration. Allethrin is *dl*-2-allyl-4-hydroxy-3-methyl-2-cyclopenten-1-one esterified with a mixture of cis and trans *dl*-chrysanthemum monocarboxylic acid.

The effort to devise a coined name for TDE (DDD), as mentioned in last year's report, has not been successful, and the Committee recommends that the use of TDE for dichlorodiphenyldichloroethane be continued. It also recommends that the Journal continue to use *n*-propyl isome, piperonyl butoxide, piperonyl cyclonene, hexaethyl tetraphosphate, and tetraethyl pyrophosphate. Although none of these names describe accurately the composition of the product they designate, they have been used sufficiently long so that their meaning is generally understood and efforts to develop other names do not seem warranted.

The Committee also recommends that when a code or trivial designation of an insecticide is used for the first time in a Journal article, the designation be accompanied by a reasonably specific chemical name. If such a designation becomes established and a name is not coined—as, for example, DDT—this procedure is no longer necessary.

It is further recommended that authors be again requested to describe clearly and specifically in their papers the nature and composition of products studied. Where mixtures, such as wettable powders and emulsions, are used for test purposes, all ingredients should be specified and the purity of the toxicants given in such a manner that the work could be repeated. In general, reports of experiments with toxicants known only by their laboratory code designation should not be given space in the journal, as they have little immediate value and none as permanent literature. The membership is asked to cooperate with the Editor in this respect.

The Committee also recommends that as a coined name is announced the editor publish this name together with a definition in an early issue of the Journal.

Harold H. Shepard
Glenn Carman
C. O. Eddy
C. W. Kearns
H. L. Haller, *Chairman*

Report of Resolutions Committee

Whereas at no time in American history has there been a greater need for complete support of the Science of Entomology, and the economic and professional future of this Science depends on the financial as well as the moral support of persons whose vocation is Entomology, therefore,

Be It Resolved that Entomologists of North America, particularly those receiving their incomes from the Science of Entomology, be urged to support the American Association of Economic Entomologists. Further,

Be It Resolved that heads of departments of Entomology in universities, agricultural experiment stations, extension divisions, regulatory agencies, heads of divisions of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, and directors of research in industrial organizations using entomological talent, call to the attention of their staffs the background, aims, and objectives of the Association, and the desirability of affiliating with it.

Your committee recommends that the Executive Committee determine ways and means of calling the substance and intent of this resolution to the attention of the proper officials.

WHEREAS a new National Science Register is required by the law establishing the National Science Foundation and the present emergency emphasizes the necessity of such a Register for the effective functioning of the Foundation, and

WHEREAS the American Institute of Biological Sciences has offered its facilities in the immediate registration of personnel in the Biological Science and has requested the assistance of the American Association of Economic Entomologists in this compilation, therefore

Be It Resolved that all Entomologists receiving a registration questionnaire be strongly urged to execute and return it promptly.

WHEREAS the responsibility for the preparation of the program for the annual meeting of the American Association of Economic Entomologists is a heavy task and must of necessity fall on but few shoulders, therefore,

Be It Resolved that the Association publicly and officially recognize its debt to the Program Committee consisting of L. D. Christenson, H. G. Johnston, and Floyd Andre for its development of the stimulating program presented at this meeting.

WHEREAS the Committee on the Local Arrangements has worked untiringly on the innumerable mechanical details attendant to a conference of this magnitude, therefore,

Be It Resolved that the Association express its sincere appreciation to Messrs. George M. List, Claude Wakeland, W. E. McCauley, B. T. Snipes, Jim R. Dutton, Huge G. Rodek, and F. H. Gates of this committee for their excellent arrangements for this Sixty-Second Annual meeting of the Association.

WHEREAS The Julius Hyman and Company and The Shell Chemical Corporation have graciously tendered to the members of our Association a complimentary banquet which was thoroughly enjoyed by those attending. Therefore,

Be It Resolved that the Association instructs the Secretary to send to these companies an expression of appreciation on behalf of the Association for this not inconsiderable addition to the entertainment program of this meeting.

WHEREAS The agricultural chemical industry has generously provided funds for the annual banquet entertainment, the cocktail party, and ladies luncheons and tours, therefore,

Be It Resolved that the Association hereby records its real appreciation for this assistance, which has added materially to the success of the meeting.

WHEREAS The Julius Hyman and Company of Denver, Colorado, through its capable staff, has given freely of time and talent toward the handling of many of the details attending the management of this successful meeting, therefore,

Be It Resolved that the Secretary be instructed to express the sincere thanks of the Association to this company for its assistance.

WHEREAS the cooperation of the management and employees of the Cosmopolitan Hotel has been an important factor in the success of this annual meeting, therefore

Be It Resolved that the Secretary shall suitably convey to the Cosmopolitan Hotel an expression of appreciation from the Association for assistance in arranging for this most satisfactory and enjoyable Sixty-second Annual Meeting.

E. H. LITTOOY
J. J. DAVIS
H. B. MILLS, *Chairman*

REPORT OF THE COMMITTEE ON COMMON NAMES OF INSECTS

During the year 1949, the Committee on Common Names of Insects proposed 47 names for addition to the official list and substitute names for 6 which had been previously included. In accordance with recently established policy these names were published in the JOURNAL OF ECONOMIC ENTOMOLOGY (vol. 42, pp. 1003–1004, 1949) and a period of 30 days was allowed for the receipt of objections to the proposals. Two such objections were received and the names involved have been reconsidered by the committee this year. As a result, the committee agreed that the common name for *Scutigerella immaculata* (Newp.) should remain garden centipede. With this exception, the names referred to above are now part of the official list.

During 1950, 23 names which had been proposed for addition to the list were also considered by the committee. Of these, only 8 received the necessary approval of 7 or more members of the committee. Nearly all of the remaining 15 names were rejected because of inappropriateness. At the present time 27 proposals for additions to the list and 11 proposals for changes in previously approved names are being prepared for circularization in the committee.

In response to a question submitted by a member of the Association the Committee considered the question as to whether in establishing an official list of common names it was at the same time establishing an official list of corresponding scientific names. The committee agrees that this is not the case. Scientific names are subject to rules of nomenclature and to taxonomic procedures involving reclassification which are beyond the committee's jurisdiction. On this basis, scientific names have been revised from list to list on the basis of the best available advice without the formality of committee approval. Although the scientific names in the list may well serve as a useful guide to the nontaxonomist it is inevitable that some of them will become out of date shortly after publication of each list.

At the last annual meeting, this committee was instructed to prepare a revised list of approved common names for insects for early publication. This list was prepared for the committee by C. F. W. Muesebeck and appeared in the February number of the JOURNAL OF ECONOMIC ENTOMOLOGY (vol. 43, pp. 117–138, 1950). The committee wishes to express its appreciation to Mr. Muesebeck for having undertaken this task.

C. F. W. MUESEBECK — T. A. BRINDLEY
T. L. AAMODT — F. E. WHITEHEAD
R. K. FLETCHER — G. J. HAEUSSLER
A. N. TISSOT — R. GLEN
E. G. LINSLEY, *Chairman*

REPORT OF THE JOINT COMMITTEE ON THE PREPARATION OF A HISTORY OF ENTOMOLOGY IN WORLD WAR II

The Committee is pleased to report that substantial progress has been made on the preparation of a History of Entomology in World War II, and it is now hoped that the first draft of the manuscript can be placed in the hands of the Executive Committees early in 1951. Two members of the Joint Committee (Knipling and Oman) have reviewed the first draft of the History. It is planned to have the first complete draft of the History reviewed in detail by the Joint Committee before the manuscript is referred to the Executive Committees.

STANLEY W. BROMLEY
RALPH W. BUNN
E. F. KNIPLING, *Co-Chairman*
PAUL W. OMAN, *Chairman*

REPORT OF REPRESENTATIVE TO THE NATIONAL RESEARCH COUNCIL DIVISION OF BIOLOGY AND AGRICULTURE

Your representative attended the annual meeting of the Division of Biology and Agriculture held on May 9, 1950, at the National Academy of Science Building, Washington, D. C.

Committee reports included those on the subject of Aerobiology, American Type Culture Collections of pathogenic organisms, Radiation Biology, Waste Disposal with respect to the effects on shore developments and on fish and wild life, and Nutrition of Man and Domestic Animals. The Committee of Food Protection is concerned with the standardization of safeguards to prevent contamination of crops in the field and of processed food in various stages of movement to the consumer. A newly-formed Committee on Conservation of Replaceable Resources will be concerned with ground water shortage, soil erosion, soil deficiencies, and plant and animal resources. The committees on food protection and on conservation touched upon problems of entomological interest.

The Institute has nearly completed for publication the first section of the Handbook of Biological Data which will consist of tables and other subject matter on blood. Your representative as a member of the Panel of Appraisers rated a 150-page group of tables and other data from an entomological viewpoint which are being prepared for a second section of the Handbook.

The Committee on National Research Council Fellowships considered 46 applications and recommended 12. No entomologists were among the three finally granted awards.

The Committee on Fulbright Fellowships acted on 130 applications for awards in research and teaching in foreign countries and recommended 32. Although 5 applications of entomologists were in the group all were rejected. At least one successful candidate occurred in each of the 8 other groups of applicants. The Committee pointed out that the quality of candidates was higher than in former years; also that certain deserving candidates were not placed because suitable openings were lacking. The exchange program for the academic year 1951–1952 has just been announced and applications for Fulbright Fellowships should be in the hands of the National Research Council before January 15, 1951.

In response to a request from the Bureau of the Budget the Institute made a survey to determine the amount of money that could be allocated to biological research by the National Science Foundation. It was estimated that $6,000,000 per annum could be advantageously spent on research in the field of biology after the program is fully under way.

The Institute is assisting in the new National Science Register by developing check lists of scientists in biology and agriculture. The National Security Resources Board has asked the National Academy of Sciences for recommendations of a program to best utilize the highly trained scientists. While the recently-passed Gurney Bill provides for the registration and drafting of members of the medical, dental and related professions it also provides for the deferment of students in these same fields. By this act it is evident that Congress recognizes the need for uninterrupted training of students in the healing arts and scientific fields.

Respectfully submitted,
FLOYD F. SMITH

REPORT OF COMMITTEE ON ILLUSTRATIVE MATERIAL

The membership of the Association desires that the best possible illustrative material be prepared and used at the meetings. Lantern slides constitute the major amount of such material. The common faults with slides are: The lettering on the slides is too small, too crowded, and designed to cover too much information on each slide.

To stimulate interest in the improvement of illustrative material a resolution was introduced and accepted at the last annual meeting. The resolution authorized the incoming president of the association to appoint a committee to make recommendations on how best to improve the preparation and presentation of graphic and tabular material.

After due consideration the committee wishes to submit the following report, which is in four parts:

1. Specifications for the preparation and use of projection materials.
2. Means for stimulating membership to follow the specifications.
3. Procurement of certain equipment.
4. Suggestions for local committees on arrangements.

The specifications which were prepared by the committee have been duplicated and a copy submitted to each person who submitted a title for a paper to be presented at the meeting. A few additional copies were distributed to the heads of Departments of Entomology at the various colleges and universities. Additional copies may be obtained from the Secretary of the Association.

As a means of stimulating the use of the specifications by the membership the committee recommended that the specifications for making slides be printed in the Journal and that a number of reprints be made available and in the future the Secretary or Chairman of the Program Committee should send a copy of the reprint to each person submitting a title for a paper to be presented at each Annual Meeting. Members preparing papers for presentation at branch meetings should follow these same specifications for illustrative material.

The heads of Departments of Entomology or

those in charge of the various units of entomologists should assume the responsibility of having slides made by their people and prepared in accordance with the specifications.

The committee was asked to recommend that a reviewing board be set up to examine all slides and discard those not meeting the specifications. It was felt desirable, however, to first try improving the quality of the slides by having members in responsible positions improve their slides and those of their subordinates.

In relation to the purchase of equipment, your committee recommends the purchase of one 12×12 white matte screen and suitable supports, one suitable pointer 12 ft. long, a shipping case for screen, supports, and pointer, one projector for 2×2 slides, equipped with a 1,000 watt, 115 volt lamp and a 5 inch f3:5 lens with shipping case. This equipment would serve the general session or a large section meeting. The cost of the above equipment would be about $300.00. Your Committee on Illustrative Material recommends also that the local committee on arrangements be authorized to incur the expenses necessary to rent additional equipment adequate to the needs of the meetings. Such equipment should be modern and of sufficiently high power to give clear, clean-cut images.

The importance of the local committee on arrangements cannot be overlooked and much of the success of the meetings depends on the work of the local committees. Quite often it is the oversight of some relatively small item that disrupts the meeting the most; therefore, your Committee on Illustrative Material has prepared a list of items for the consideration of the local committee, copies of which are in the possession of the Secretary. It is recommended that each year in the future the Secretary send to the Chairman of each local committee on arrangements at the time he is notified of his assignment as chairman a copy of the suggestions and inform him that he has authority to incur expenses necessary to provide suitable projection equipment.

J. L. HORSFALL
CHAS. E. PALM
M. P. JONES, *Chairman*

SUGGESTIONS TO LOCAL COMMITTEES ON ARRANGEMENTS, WITH REGARD TO PROJECTION EQUIPMENT AND ITS USE

EQUIPMENT

Projectors

One 2 by 2 projector for each conference room. The projector in the main conference room should be equipped with a 1,000 watt 115 volt lamp and a 5 inch f3:5 lens. For the smaller conference room a 300 to 500 watt projector should suffice.

Standard size projector for 3¼×4 inch slide.

One for each conference room where program indicates 3¼×4 inch slides will be used.

Screens

A white matte for beaded screen at least 12 feet by 12 feet for the main conference room.

A 6 by 8 foot, or preferably larger screen, for each of the smaller conference rooms.

Pointers

One suitable pointer for each room.

The length of stick pointers should be equal to the width of the screen.

Indicators

In each room a suitable device should be provided for use by the speaker in signalling the lantern operator to change the slides.

Microphones

One for each larger conference room. Provide a lapel or breast microphone or a portable one for use of the speaker when he is using slides and talking from the screen.

Extension Cords

Ample extension cords for projectors and enough to permit the speaker to carry microphone with him when he points out objects on the screen.

OPERATIONS

Have each projector set up and in working order before the start of the conference where it is to be used.

Have someone present to keep loud speaking equipment in operation. Test the machine prior to the meeting by projecting a few slides.

An operator should be provided for the projection equipment in each conference room. He should be familiar with the equipment he is to operate.

Have some one person designated to operate the window shades wherever necessary.

Make provision to have screen visible to entire audience, not obstructed by lamps, rostrum or officers. Place screen high enough to be visible to all.

Dr. J. H. HORSFALL
Dr. C. E. PALM
Mr. M. P. JONES, *Chairman*

RECOMMENDATIONS BY COMMITTEE ON LANTERN SLIDE MATERIAL

In order that papers presented at National and Branch Meetings may be as effective as possible, it is strongly urged that all speakers using illustrative material follow closely the suggestions given below. These recommendations, if adhered to, will insure that the data presented on the screen will be readily legible to the audience and will add greatly to the effectiveness of the presentation.

Lantern Slides

Slides are merely aids in presenting a talk. To be of value they must be prepared so that when projected they will be easily read and quickly understood. Tests have shown that in a fairly dark room, with good projection, when bold block letters are used in making the slides the enlarged projected letters can be read as indicated.

1-inch letters are easy to read 25 feet from screen.
2-inch letters are easy to read 50 feet from screen.
4-inch letters are easy to read 100 feet from screen.

Letters of the foregoing sizes can be read at greater distance but become tiresome to follow. In many rooms where slides are shown there are people more than 100 feet from the screen.

KIND OF SLIDES—2 by 2 inch and 3¼ by 4 inch.

2 by 2 inch (black and white, and color)

2 by 2 inch size is preferable, if made by photography.

More convenient for alternating the projection with color slides.

White lettering on black background sometimes preferred.

Lettering thirty ¼-inch letters in a 7½-inch line, then reducing this to a $1\frac{3}{16}$-inch line on the field of a 2 by 2 slide and projecting this to a 10-foot line on the screen will make the projected letters about 4 inches in size.

3¼ by 4 inch (old standard size)

To be used only when photographic process is impracticable.
To be used where lettering, drawing, etc., is made on slide.
When lettering is done by typing, use pica-size type or larger.
To get a 4-inch letter on the screen from pica type the 3¼ by 4-inch slide will have to be enlarged about 40 diameters or to the field of an 8 by 10 foot screen.
Materials such as Radio-Mat[1] are satisfactory for making direct typewriting slides.

LEGIBILITY OF SLIDES

Style of lettering

Plain, bold, block hand lettering in black can be more easily read than italic, script, or fancy types.
Gummed black letters can be substituted.
Typing for use in making slides will not stand reduction and then the necessary enlargement.

Spacing

Crowded letters or words reduce legibility.
Use not more than 30 letters and spaces horizontally.
Use not more than 10 lines vertically.
Leave ample space around words, figures, and characters.

Weight of letters and trend lines

In making ¼-inch letters use number 3 or 4 Leroy or number 2 or 3 Wico pen.
Use comparable or heavier weight lines for trend lines in graphs.

COMPOSITION OF SLIDES—Tables, Charts, Pictures, and Drawings

Tables

Should contain only essential data. Preferably one or two main items.
Summaries are sufficient in most cases.
Limit headings to four words.
Include only one general thought in heading.
Repeat subheads on continuing slide if additional slides are needed to complete the table.
Do not shift position of any columns of figures on succeeding slides.
If first slide carries check plot information on left, use this order on continuing slides.
Leave ample space for emphasis.
Inclusion of many data makes essential material less obvious.

Charts: Graphs, columns, pies, bars.

Keep them simple.
Use least lettering possible.
Select kind most appropriate to subject.
Graphs.
Do not exceed three trend lines per graph.
Make trend lines distinct and contrasting by using solid lines, dots and dashes, or different-colored lines.
Trend lines need not pass through all variable points.
Columns, pies and bars.
In color slides, alternate colors add to clarity and attractiveness. Use black, red, blue, orange, green, or purple and in that order.
Shading by various patterns gives contrast to the different units when using black and white.

Pictures of objects

Items photographed to clarify talk should be plainly visible.
Use no more than two or three typical samples.
When taking pictures, use a contrasting background.
Be careful of strong lights and shadows.
Omit meaningless foreground subjects.
Leave out unrelated material, such as posts, steam pipes, automobiles, and irrelevant equipment.
Posing should show action related to subject matter.
Leave portraits for your album.
Mask out all except the points to be stressed when copying photographs for use in slides.

Drawings and sketches

Drawings may illustrate some items better than photographs.
Sketches of objects being discussed help others to visualize points being stressed.

USING SLIDES

Examine each slide before going to meeting.
Make sure there is no error in subject matter.
Make sure slide is properly marked for lantern operator. To do this hold the slide in the correct position for reading when the maker looks through it, then place the tab on the lower left-hand corner next to him.
Stand to one side of the screen.
Talk to audience, not to screen.
Explain general lay-out.
Place pointer on each feature referred to.
Use more slides rather than too much on one slide.
Do not dwell too long on one slide.

[1] Radio-Mat is a combination of a thin sheet of transparent plastic material, a sheet of special carbon paper, and a mask with proper slide apertur. . This combination is inserted in the typewriter and data for the slide are typed within the masked aperture. The carbon paper is removed and the plastic sheet carrying the typed data and the mask are mounted in conventional manner between sheets of glass to prepare the finished lantern slide. A slide prepared with Radio-Mat automatically limits the number of lines per slide and is readable from all parts of the room. This combination can be purchased from dealers handling photographic equipment or from Radio-Mat Slide Co., Daytona Beach, Florida.

REPORT OF THE MEETING OF THE SECTION OF APICULTURE

The Section of Apiculture met in the Club Room of the Cosmopolitan Hotel, Denver, Colorado, Wednesday afternoon, December 20, 1950. In the absence of Dr. J. A. Munro, Fargo, N. D., Chairman, Dr. R. L. Parker, Manhattan, Kansas, was elected acting Chairman and called the meeting to order at 1:35 P.M.

The following papers were presented:

1. Population and Behavior Studies of Some Insect Pollinators of Apples in Washington. H. F. Menke, Pullman, Washington.

2. A Pedigree System for Honey Bees. W. C. Rothenbuhler, J. W. Gowen, and O. W. Park, Ames, Iowa. Presented by O. W. Park.

3. Time Factors in Mating Systems for Honey Bees. M. S. Polhemus and O. W. Park, Ames, Iowa. Presented by O. W. Park.

4. Relationship of Some Weather Factors to the Honeyflow. J. O. Moffett Jr., Ft. Collins, Colorado, and R. L. Parker, Manhattan, Kansas. Presented by J. O. Moffett.

5. Pollination of Legumes at Varying Distances from Honey Bee Colonies. R. J. Walstrom, F. B. Paddock, and O. W. Park, Ames, Iowa. Presented by O. W. Park.

6. Honey Bee Activity on Alfalfa, *Medicago sativa*, in Relation to Sugar Content of Nectar, and to Various Environmental Factors. B. A. Haws and O. W. Park, Ames, Iowa. Presented by O. W. Park.

7. A Survey of Beekeeping in Hawaii. J. E. Eckert, Davis, Calif. Presented by H. F. Menke, Pullman, Washington.

8. The Status of Bumble Bees in Relation to the Pollination of Red Clover in New Zealand. B. E. Montgomery, Lafayette, Indiana. Presented by Curtis Wilson, also of Lafayette.

9. Inversion of Cane Sugar in the Honey Stomach of the Bee. E. Oertel, E. A. Fieger, V. R. Williams, and E. A. Andrews, Baton Rouge, Louisiana. Summary read by R. L. Parker, Manhattan, Kansas.

10. Effects of Various Acaricides on Honey Bees. L. D. Anderson, Riverside, Calif.

H. F. Menke, Pullman, Washington, and W. W. Franklin, Hays, Kansas, the Resolutions Committee, presented the following resolutions, all of which were approved on the floor:

1. Resolved: That the incoming officers try to select some one time for the meeting of research workers in beekeeping and pollination, instead of dividing forces among the annual meeting of the American Beekeeping Federation, the Pollination Conference, and the Section of Apiculture Meeting of the American Association of Economic Entomologists.

2. Resolved: That the Secretary inform the Cosmopolitan Hotel and the local Arrangements Committee of our appreciation for the excellent meeting facilities.

3. Resolved: That honey should be included in the menu of the annual banquet of the Association's 1951 meeting, and that in order to insure such inclusion, the Secretary inform the local Arrangements Committee of this resolution.

4. Resolved: That in view of the extreme importance of the honey bee in pollinating agricultural crops, the Section of Apiculture of the American Association of Economic Entomologists second the recommendation of the Pollination conference or the American Beekeeping Federation requesting an Extension Apiarist in the Federal service.

5. Resolved: That this Section give a rising vote of thanks to the outgoing officers in appreciation of their faithful service.

O. W. Parks, Ames, Iowa, and J. D. Hitchcock, Laramie, Wyoming, and Nominations Committee, presented the following nominees for the ensuing year, and they were unanimously elected:

Chairman: W. A. Price, Department of Botany, University of Kentucky, Lexington, Kentucky.
Secretary: R. L. Parker, Department of Entomology, Kansas State College, Manhattan, Kansas.

The attendance was 33 persons from 14 states and Mexico. The meeting adjourned at 5:30 P.M.

J. D. HITCHCOCK, *Acting Secretary*

REPORT OF THE SECTION OF TEACHING

A list of nineteen questions had been submitted to Doctor Hixson, who presided, principally by the members of the panel selected to consider them. These appeared in the printed program, and they are thus available to members who are interested. The sequence employed in discussing these questions was as follows: 10, 2, 5, 14, 15, 16, 4, 19, 11, 6, 7, 8, 9, 13, 12, and 1.

The most significant points brought out in the discussion were, in my opinion:

a. That there is indeed interest in maintaining the teaching section and in the employment of a roundtable discussion by a panel together with voluntary comments by other members.

b. That the panel should include some members not primarily concerned with teaching (for example, a man from experiment station, one from extension, one from U.S.D.A., and possibly one from commercial group) and that the program should not be too general, but be more thorough on a few selected subjects.

c. That there is a need for a textbook in economic entomology which (1) is up-to-date on control measures, (2) is of convenient size and form, and (3) is inexpensive.

d. That taxonomy might well precede the course in morphology, and that the latter should not be merely a service course for taxonomy.

e. That all agriculture students should be required to take at least one course in economic entomology.

f. That we can cooperate more fully with extension and 4-H club workers in getting the young people interested in the study of insects. Also, encourage the study of insects in the elementary and secondary schools.

The election of officers for the coming year followed the report of the nominating committee (which consisted of George F. Knowlton, John H. Lilly, and Alva M. Peterson). The group elected by unanimous vote the following people: for chairman: Lee H. Townsend (University of Kentucky); for secretary: R. H. Davidson (Ohio State University).

J. HARVEY ROBERTS, *Secretary*

REPORT OF THE MEETING OF THE SECTION OF PLANT PEST CONTROL AND QUARANTINE

The meeting of the Section on Plant Pest Control and Quarantine, of the American Association of Economic Entomologists, was held in the Silver Glade Room, Cosmopolitan Hotel, Denver, Colorado, Monday, December 18, 1950. The Chairman, A. P. Messenger, was unable to attend and the Secretary, H. S. Dean presided at the Chairman's request. The section was called to order at 1:45 P.M. After making several announcements the Acting Chairman appointed a nominating committee consisting of H. M. Harris, E. L. Chambers, and R. G. Richmond, Chairman. The following papers were then presented:

1. Plant Quarantine Problems Relating to the European Corn Borer. H. M. Harris, State Entomologist, Ames, Iowa
2. Cyst Forming Plant Nematode Pests and How They are Spread. G. Steiner, Division of Nematology, Bureau of Plant Industry, Soils and Agricultural Engineering, Washington, D. C.

3. Changing Problems and Procedures in Grasshopper and Mormon Cricket Control. Claude Wakeland, Division of Grasshopper Control, Bureau of Entomology and Plant Quarantine, Denver, Colorado.
4. The Possibility of Introducing Insects Through Air Traffic. John H. Hughes, Entomologist, Division of Foreign Quarantine, U. S. Public Health Service, Washington, D. C.
5. Spruce Budworm Control in Oregon and Washington. J. M. Whiteside, Entomologist, Forest Insect Laboratory, Portland, Oregon.

Submitted Papers

6. Emergency Insect Control in North Dakota. J. A. Munro and R. L. Post, North Dakota Agricultural College, Fargo, N. D.
7. A New Concept in the Vapor-Heat Sterilization of Fruit for Fruit Flies. W. E. Stone, F. Servin and I. Heins, Bureau of Entomology and Plant Quarantine, Mexico City, Mexico.
8. Dips for the Citrus Blackfly as a Possible Treatment for Mexican Limes Boxed for Export. J. G. Shaw, M. Oritz, R. Doelker, and R. Villasenor, Bureau of Entomology and Plant Quarantine, Mexico City, Mexico.

There was some discussion of several of the papers. The session was well attended, it being estimated that over 100 were present.

The nominating committee submitted the following names for officers for 1951:

J. W. Baringer, Chief, Division of Plant Industry, State Department of Agriculture, Columbus 15, Ohio.

H. S. Dean, Bureau of Entomology & Plant Quarantine, U.S.D.A., Washington 25, D. C.

The nominations were accepted and the nominees elected.

H. S. DEAN, *Secretary*

REPORT OF THE MEETING OF SECTION OF MEDICAL ENTOMOLOGY

The first session of the Section of Medical Entomology was called to order by the Chairman, E. Harold Hinman, December 18, 1:30 P.M., in the Century Room of the Cosmopolitan Hotel in Denver. Due to the absence of B. V. Travis, D. E. Howell was selected as acting secretary. A nominating committee composed of A. D. Hess, W. V. King and Doyle Reed was appointed.

Four invitation and four submitted papers were presented as follows:

Invitation Papers

1. The Expert Committee on Insecticides of the World Health Organization. S. W. Simmons, U. S. Public Health Service, Savannah, Ga.
2. The Newer Insecticides and Repellents Available Against Insects of Medical Importance. W. V. King, Bureau of Entomology and Plant Quarantine, Orlando, Florida.
3. Tick Transmission of Indian Tick Typhus and Some Related Rickettsioses. Cornelius B. Philip, Rocky Mountain Laboratory, U. S. Public Health Service, Hamilton, Montana.
4. Naval Automatic Disinsection of Aircraft. J. M. Hurst, Lt. Com. (MSC), Malaria and Mosquito Control Unit No. 1, U. S. Naval Air Station, Jacksonville, Florida. (Read by A. D. Hess)

Submitted Papers

1. The Mosquito Survey and Control Program: Guam M. I., 1945. Stanley F. Bailey and Richard M. Bohart, University of California, Davis.
2. The Chigger Problem in City Lawns with Suggestions for Their Control. Dwight M. DeLong and James F. Smith, Ohio State University, Columbus.
3. Host Relationships and Seasonal Abundance of Some Southwest Georgia Ectoparasites. Harvey B. Morlan, U. S. Public Health Service, Thomasville, Georgia.
4. *Amblyomma americanum* as a Vector of Tularaemia. C. E. Hopla, University of Kansas, Lawrence, Kansas.

During the business session which followed the paper reading session, E. F. Knipling was selected as chairman and D. E. Howell as secretary. The chairman appointed a steering committee composed of K. D. Quarterman, chairman, Doyle Reed and R. L. Metcalf to assist the elected officers with the activities of the section in 1951.

Chairman E. Harold Hinman announced that he had appointed E. F. Knipling, J. W. Hughes and R. L. Metcalf to assist S. W. Simmons in his duties as a member of the expert committee on insecticides of the World Health Organization and Dr. Simmons requested that it continue to function.

The second session met Tuesday, December 19, 1:30 P.M. in the Silver Glade Room. Robert Pfadt served as designated chairman. The following papers were presented:

1. Ecology of American Arctic and Subarctic Mosquitoes. Dale W. Jenkins, Medical Division, Army Chemical Center, Maryland.
2. Dispersal and Flight Range of Northern Mosquitoes Traced with Radioisotopes. Dale W. Jenkins, Medical Division, Army Chemical Center, Maryland.
3. Flight Habits of Three Species of Flies Tagged with Radioactive Phosphorus. A. W. Lindquist, W. W. Yates, and R. A. Hoffman, Bureau of Entomology and Plant Quarantine, and J. S. Butts, Oregon State College, Corvallis.
4. The Status of Insecticide-Resistant Houseflies in Southern California. Ralph B. March and Robert L. Metcalf, University of California Citrus Experiment Station, Riverside.
5. A Method of Testing the Resistance of Houseflies to Residual-Type Insecticides. Dale R. Lindsay and Thomas W. Haines, Communicable Disease Center, Public Health Service, Thomasville, Georgia.
6. The Effect of Temperature, Humidity, and Weathering on the Residual Toxicities of Five Organic Insecticides to the Adult Housefly. T. P. S. Teotia and Paul A. Dahm, Kansas Agricultural Experiment Station, Manhattan.
7. Dieldrin as a Chemical Control Measure in Community Fly Control Program. H. F Schoof, R. E. Siverly, and J. H. Coffey, U. S. Public Health Service, Federal Security Agency, Atlanta, Georgia.
8. Cable-Type Back Rubbers for Horn Fly Control. Wm. M. Rogoff, South Dakota State College Experiment Station, Brookings.
9. Tabanid Control on Dairy and Beef Cattle with Synergised Pyrethrins. W. N. Bruce and

George C. Decker, Natural History Survey, Urbana, Illinois.

10. Determination of Toxaphene Emulsions in Dipping Vats. E. W. Laake and J. C. Clark, Bureau of Entomology and Plant Quarantine, Kerrville, Texas.

A 32 minute film entitled, "More Meat for More Millions" was introduced and discussed by E. W. Laake at the conclusion of the paper reading session.

D. E. HOWELL, *Acting Secretary*

REPORT OF THE SECTION ON INSECTICIDES

Chairman—BRUCE GLEISSNER, *American Cyanamid Co.*

The program committee, with Fred Fletcher of Dow Chemical Company as chairman, arranged for three invitation papers, which were presented during the first part of the program on Wednesday morning, December 20, 1950.

No. 1—"Criteria for Measuring Phytotoxicity of Insecticides and Their Mode of Action" was presented in two parts. The first part by T. C. Allen and the second part by J. E. Casida, both of the Department of Economic Entomology, University of Wisconsin, Madison. Two standardized laboratory procedures for measuring phytotoxicity were reported. The first, involving the straight growth of stem sections of pole beans, has been used to compare the relative phytotoxicity or stimulation by a large series of chlorinated hydrocarbon insecticides as compared with arsenic trioxide and 2,4-D standards for their respective phytotoxic and stimulatory action. The second method depends upon the inhibition of root growth of cucumber seedlings. Results, utilizing these methods, indicate that the phytotoxicity of technical DDT may be associated with various factors which include the pH of the solution, the impurity 2-(p-chlorophenyl)-1,1,1-trichloroethanol, and the possible breakdown of DDT to 4,4'-dichlorodiphenyl acetic acid.

No. 2—"The Environment Health Aspects of Agricultural Pesticides" by Frank Princi, Associate Professor of Industrial Medicine, University of Cincinnati, Cincinnati, Ohio. Agricultural pesticides were considered in three groups: (1) inorganic insecticides, (2) organic phosphates and (3) chlorinated hydrocarbons.

DDT as a member of the last group was discussed more fully than any others; first, because DDT has been investigated more thoroughly by toxicologists than any other organic compound and second, because a common-sense attitude adopted for DDT might serve as a guide for the consideration of compounds in the future. There has been disagreement among toxicologists regarding the interpretation of experimental data on DDT. In view of the valuable and extensive human experience obtained by the use of tremendous quantities of DDT since 1942, the speaker questioned such statements as the "potential hazard of DDT may have been underestimated." Feeding of small amounts of DDT to rodents has caused liver damage in rodents but similar small amounts fed to other species has not been shown to result in liver damage.

Mere storage of DDT in body fat was not considered an unusual factor since many toxic materials are known to be stored in body tissues without deleterious effect. The body fat of DDT workers has been shown to contain up to 900 ppm and 50 ppm has been found in the body fat of individuals not known to have ever been in contact with DDT. In spite of this, DDT damage to the human liver has not been observed.

The speaker also questioned the statement that "dieldrin and aldrin are approximately 10 times more poisonous when applied to the skin than when swallowed," since other investigators find that the reverse is true and that the compounds have been used safely in spite of contamination of the skin.

The example was mentioned of nitrogen trichloride being forbidden by law for the bleaching of flour in spite of 30 years safety record with humans, simply because it could be demonstrated that the compound caused running fits in dogs.

In evaluating toxicity hazards all the data and experience should be considered. Differences between species ought to be recognized and evidence obtained with experimental animals should not outweight all the other information available.

No. 3—"Review of the Residue Tolerance Hearing and a Discussion of the Mechanics of Preparing the Findings of Fact and Regulations and Some of the Problems that are Involved" by Bernard D. Levinson, Presiding Officer, Federal Security Agency, Washington, D. C. There were 82 hearing days from January 17 to September 15, 1950. A total of 255 witnesses presented 9000 pages of testimony and 1400 exhibits. In the first category, "necessity for use," 90 entomologists testified regarding "what chemicals are necessary for what crops." The second category concerned the toxicity of the substances which were found to be necessary in the protection of fresh fruits and vegetables. Forty-three pharmacologists presented evidence which should help to answer the question, "What should tolerances for residues be?" On the toxicity phase of the hearing, some insecticide substances were recognized as harmless or of such low order of toxicity that it was not necessary to take evidence with respect to toxicity.

The hearing was the first step in establishing regulations for the conduct of the entire industry. After careful study of the evidence contained in the record by qualified experts, the Administrator will publish the tolerances in the Federal Register. There is a provision for the filing of exceptions, and the final order will probably not be published in time to effect the 1951 growing season. The law authorized the establishment of tolerances for the protection of public health. There are bound to be points of conflict between the interest of growers and manufacturers of agricultural chemicals on one hand and in the interest of the public on the other. Obviously these must be resolved in favor of public health.

The presentation of new insecticides has become a regular feature of this section.

(1) Sulfox-cide was announced by S. B. Penick & Company. Chemically this material is the n-octyl sulfoxide of isosafrole. It was recommended for use as a synergist in combination with pyrethrins and allethrin in household sprays and aerosols.

(2) Systox was announced by Geary Chemical Corporation. Chemically it is a trialkyl thiophosphate. It was recommended as a systemic insecticide for aphids and mites.

(3) Potasan was also announced by Geary Chemical Corporation. The chemical name for the compound is diethoxy thiophosphoric acid ester of 7-hydroxy-4-methyl coumarin. It was recommended against Colorado potato beetle, Mexican bean beetle and red spider mite.

(4) Compound 4049 was announced by American Cyanamid Company. The chemical name for the compound is S-(1,2-dicarbethoxyethyl) 0,0-dimethyl dithiophosphate. It is much less toxic to mice and rats than parathion but its insecticidal activity approaches that of parathion.

(5) Dilan was announced by Commercial Solvents Corp. Chemically it is a mixture containing 2 parts of 2-nitro-1,1-bis-p-chlorophenyl butane and 1 part of 2-nitro-1,1-bis-p-chlorophenyl propane. The material was recommended for Mexican bean beetle, coddling moth, corn earworm, corn borer and Oriental fruit moth.

At the business meeting the secretary read a report submitted by Jack E. Fahey, Chairman of the Methods Committee. This report covered 3 projects as follows:

(1) Methods of Sampling for Chemical Analysis of Spray Residues. A bibliography of methods of sampling for chemical analysis of spray residues is being completed.

(2) Standardization of Test Insecticides was reported on by Geo. S. Kido. The following chemicals have been selected for distribution: chlordane, p,p′ DDT, methoxychlor, lindane, toxaphene, parathion and tetraethyl pyrophosphate.

(3) Biological Laboratory Methods of Insecticide Evaluation reported on by Philip Wallace. This project will be continued in cooperation with the National Research Council.

The nominating committee made up of Donald Ashdown, chairman: C. R. Persing and G. F. Ludvik presented the following slate of officers, which was elected by the section:

Chairman—C. J. WEINMAN *of the Illinois Natural History Survey*
Secretary—J. E. BUSSART *of Velsicol Corporation*

Respectfully submitted,
DONALD F. STARR, *Secretary,*
Section on Insecticides

REPORT OF THE SECTION OF EXTENSION

The section was called to order at 7:30 P.M. by H. L. Parten, Secretary, acting chairman for C. F. Stiles who was absent.

T. L. Aamodt discussed the importance of clarifying the areas of responsibility of the State Regulatory Service and the Extension Service so as to avoid duplication of effort and friction and at the same time reduce the cost of service to the taxpayer. There are plenty of problems for both services. Both services are educational but only the Regulatory has police powers and can authorize a tax levy by county governments for pest control.

H. M. Armitage read a paper on "Labeling Insecticides." He stressed the importance of "labels and the information that they should contain."

State pesticide laws should be uniform so as to reduce the labeling cost to the manufacturer. State laws should be designed to protect the public within the state and also help to enforce the federal laws. Registration of the label is to assure value for the use intended and claimed, and to give protection against the hazards of use.

E. H. Fisher discussed the value of combining fertilizer and insecticides in alfalfa seed production. By using research results in two different fields he was able to set up a good demonstration of their value.

George Knowlton discussed and used slides showing the mortality of honey bees working in fields of alfalfa and red clover treated with various insecticides. Parathion, dieldrin, lindane, chlordane, and DDT all killed large numbers. Time of application is important in avoiding bee loss.

McCauley read a paper by W. J. Colberg titled "The Effect of Weather on the Cornborer Population During 1950." The late, cool, wet season delayed activity so that only one generation was produced and some late corn fields had no infestation. Similar situations were reported in Nebraska and Minnesota.

Dell Gates discussed the importance of the stored grain problem and reported on the methods of organizing the interested groups of Kansas for a control program. Grain stored wet caused most of the trouble.

Fred Butcher, B.E.P.Q., discussed briefly his new assignment with the P.M.A. to work on the stored grain problem. He is available for consultation on the problem.

T. R. Robb raised the question, "Do we still have a resistant fly problem?" The discussion indicated that areas having a large number of housefly generations annually had insecticide resistant flies, while more northern areas having fewer generations did not.

The election of officers for 1951 was held. H. B. Petty, Urbana, Illinois, was elected Chairman, and Ellsworth Fisher, Madison, Wisconsin, was elected Secretary.

Meeting adjourned 11:20 P.M.

EPHRIAM HIXSON, *Acting Secretary*

REPORT OF THE NOMINATING COMMITTEE, DENVER, COLORADO

Results of the mail ballot for President and Vice President, which have been announced previously, are as follows:

President—ROY E. CAMPBELL, *Alhambra, Calif.*
First Vice-President—CHARLES E. PALMS, *Ithaca, N.Y.*

Your Committee submits the following nominations for your consideration:

Vice Presidents (Chairmen of Branches and Sections):

Pacific Slope Branch, Ed. H. Littooy
Cotton States Branch, J. W. Ingram
Eastern Branch, Frank H. Lathrop
North Central States Branch, C. R. Neiswander
Southwestern Branch, H. G. Johnston
Section of Apiculture, R. L. Parker
Section of Extension, Howard B. Petty
Section of Plant Pest Control and Quarantine,
Section of Teaching, Lee H. Townsend
Section on Insecticides, Carl J. Weinman
Section on Medical Entomology, E. F. Knipling
Section of Biological Control, Alfred B. Baird

Secretaries of Branches and Sections:

Pacific Slope Branch, Leslie M. Smith
Cotton States Branch, K. P. Ewing
Eastern Branch, Byrley F. Driggers
North Central States Branch, James W. Apple
Southwestern Branch, Sherman W. Clark
Section of Plant Pest Control and Quarantine, H. S. Dean
Section of Apiculture, W. A. Price
Section of Extension, E. H. Fisher
Section of Teaching, R. H. Davidson

Section on Insecticides, J. E. Bussart
Section of Medical Entomology, D. E. Howell
Section on Biological Control, Alvah Peterson

Executive Committee:
S. A. Rohwer (Deceased 1951)
W. H. White (Deceased 1951)

Secretary-treasurer:
E. N. Cory (1953)

Committee on Membership:
L. E. Curl (1953)
S. W. Simmons (1953)
Ephriam Hixson—*Chairman*

Committee on Common Names of Insects:
A. B. Gurney (1953)
Paul O. Ritcher (1953)
Donald MacCreary (1953)
G. J. Haeussler—*Chairman*

Publications Committee:
Charles H. Martin (1953)
B. C. Dickinson (1953)
Harlow B. Mills—*Chairman*

Program Committee:
C. E. Mickel (1953)
L. D. Christenson—*Chairman*

Committee on Insecticide Terminology:
George S. Kido (1955)
H. L. Haller—*Chairman*

Trustee for Permanent Fund:
B. A. Porter (1953)

Councillor for A.A.A.S.
Roger C. Smith (1952)

Editor:
L. M. Peairs (1951)

Associate Editor:
Harry B. Weiss (1951)

Business Manager
E. N. Cory (1953)

Nominating Committee:
W. E. DOVE
RAY HUTSON (absent)
W. V. KING
DON C. MOTE
ROY G. RICHMOND—*Chairman*

December 21, 1950